



(86) Date de dépôt PCT/PCT Filing Date: 1995/03/08
(87) Date publication PCT/PCT Publication Date: 1995/09/14
(45) Date de délivrance/Issue Date: 2006/02/21
(85) Entrée phase nationale/National Entry: 1996/09/03
(86) N° demande PCT/PCT Application No.: US 1995/002669
(87) N° publication PCT/PCT Publication No.: 1995/024382
(30) Priorité/Priority: 1994/03/10 (08/209,094) US

(51) Cl.Int./Int.Cl. *C07C 257/14* (2006.01),
C07D 333/24 (2006.01), *C07D 319/12* (2006.01),
A61K 31/155 (2006.01), *C07D 317/36* (2006.01),
C07D 317/30 (2006.01), *C07D 307/16* (2006.01),
C07D 263/32 (2006.01), *A61K 31/38* (2006.01),
A61K 31/335 (2006.01), *A61K 31/215* (2006.01),
A61K 31/195 (2006.01), ...

(72) Inventeurs/Inventors:
HALLINAN, E. ANN, US;
TJOENG, FOE S., US;
FOK, KAM F., US;
HAGEN, TIMOTHY J., US;
TOTH, MIHALY V., US;
...

(54) Titre : DERIVES DE L-N⁶-(1-IMINOETHYL)LYSINE, UTILES COMME INHIBITEURS DE L'OXYDE NITRIQUE
SYNTHETASE

(54) Title: L-N⁶-(1-IMINOETHYL)LYSINE DERIVATIVES USEFUL AS NITRIC OXIDE SYNTHASE INHIBITORS

(57) **Abrégé/Abstract:**

There is disclosed a novel amino glycol derivatives of L-N⁶-(1-iminoethyl)lysine, pharmaceutical compositions containing these novel compounds, and to their use in therapy, in particular their use as nitric oxide synthase inhibitors.



(51) Cl.Int./Int.Cl. (suite/continued) *C07D 257/04* (2006.01), *C07D 233/54* (2006.01), *C07C 323/41* (2006.01),
C07C 317/28 (2006.01), *C07C 279/18* (2006.01), *C07C 259/06* (2006.01), *A61K 31/41* (2006.01)

(72) Inventeurs(suite)/Inventors(continued): TSYMBALOV, SOFYA, US; PITZELE, BARNETT S., US

(73) Propriétaires(suite)/Owners(continued): G.D. SEARLE & CO., US

(74) Agent: OSLER, HOSKIN & HARCOURT LLP

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C07C 257/14, 279/18, A61K 31/155, 31/195, C07D 333/22, 307/14, C07C 317/28, 323/41, C07D 333/20, 233/54, 317/28, 319/12, C07C 259/06, C07D 257/04, 263/32	A1	(11) International Publication Number: WO 95/24382 (43) International Publication Date: 14 September 1995 (14.09.95)
(21) International Application Number: PCT/US95/02669 (22) International Filing Date: 8 March 1995 (08.03.95) (30) Priority Data: 08/209,094 10 March 1994 (10.03.94) US (60) Parent Application or Grant (63) Related by Continuation US 08/209,094 (CIP) Filed on 10 March 1994 (10.03.94) (71) Applicant (for all designated States except US): G.D. SEARLE & CO. [US/US]; Corporate Patent Department, P.O. Box 5110, Chicago, IL 60680-5110 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): HALLINAN, E., Ann [US/US]; 135 Barton Avenue, Evanston, IL 60202 (US). TJOENG, Foe, S. [US/US]; 875 Sugar Hill Drive, Manchester, MO 63021 (US). FOK, Kam, F. [US/US]; 13146 Strawberry Way, Saint Louis, MO 63146 (US). HAGEN,		Timothy, J. [US/US]; 1920 Madison Avenue, Gurnee, IL 60031 (US). TOTH, Mihaly, V. [HU/US]; 1031 Claridge Place, Saint Louis, MO 63122 (US). TSYMBALOV, Sofya [US/US]; 8651 Gregory Lane, Des Plaines, IL 60016 (US). PITZELE, Barnett, S. [US/US]; 7924 North Tripp Avenue, Skokie, IL 60076 (US). (74) Agents: BENNETT, Dennis, A. et al.; G.D. Searle & Co., Corporate Patent Dept., P.O. Box 5110, Chicago, IL 60680-5110 (US). (81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG). Published <i>With international search report.</i>
(54) Title: L-N ⁶ -(1-IMINOETHYL)LYSINE DERIVATIVES USEFUL AS NITRIC OXIDE SYNTHASE INHIBITORS (57) Abstract There is disclosed a novel amino glycol derivatives of L-N ⁶ -(1-iminoethyl)lysine, pharmaceutical compositions containing these novel compounds, and to their use in therapy, in particular their use as nitric oxide synthase inhibitors.		

L-N⁶-(1-IMINOETHYL)LYSINE DERIVATIVES USEFUL AS
NITRIC OXIDE SYNTHASE INHIBITORS

5

Background of the Invention

10 Field of the Invention

The present invention relates to novel amino glycol derivatives of L-N⁶-(1-iminoethyl)lysine, pharmaceutical compositions containing these novel compounds, and to their
15 use in therapy, in particular their use as nitric oxide synthase inhibitors.

Related Art

20 It has been known since the early 1980's that the vascular relaxation brought about by acetylcholine is dependent on the presence of the endothelium and this activity was ascribed to a labile humoral factor termed endothelium-derived relaxing factor (EDRF). The activity of
25 nitric oxide (NO) as a vasodilator has been known for well over 100 years and NO is the active component of amylnitrite, glyceryltrinitrite and other nitrovasodilators. The recent identification of EDRF as NO has coincided with the discovery of a biochemical pathway by which NO is
30 synthesized from the amino acid L-arginine by the enzyme NO synthase.

NO is the endogenous stimulator of the soluble guanylate cyclase and is involved in a number of biological
35 actions in addition to endothelium-dependent relaxation including cytotoxicity of phagocytic cells and cell-to-cell communication in the central nervous system (see Moncada et

2184691

2

al, Biochemical Pharmacology, 38, 1709-1715 (1989) and
Moncada et al, Pharmacological Reviews, 43, 109-142 (1991).

It is now thought that excess NO production may be involved
in a number of conditions, particularly conditions which
5 involve systemic hypotension such as toxic shock and therapy
with certain cytokines.

The synthesis of NO from L-arginine can be inhibited by
the L-arginine analogue, L-N-monomethyl-arginine (L-NMMA)
10 and the therapeutic use of L-NMMA for the treatment of toxic
shock and other types of systemic hypotension has been
proposed (WO 91/04024 and GB-A-2240041). The therapeutic
use of certain other NO synthase inhibitors apart from L-
NMMA for the same purpose has also been proposed in WO
15 91/04024 and in EP-A-0446699.

It has recently become apparent that there are at least
three types of NO synthase as follows:

(i) a constitutive, Ca^{++} /calmodulin dependent enzyme,
20 located in the endothelium, that releases NO in response to
receptor or physical stimulation.

(ii) a constitutive, Ca^{++} /calmodulin dependent
enzyme, located in the brain, that releases NO in response
to receptor or physical stimulation.

25 (iii) a Ca^{++} independent enzyme which is induced after
activation of vascular smooth muscle, macrophages,
endothelial cells, and a number of other cells by endotoxin
and cytokines. Once expressed this inducible NO synthase
synthesizes NO for long periods.

30

The NO released by the constitutive enzymes acts as a
transduction mechanism underlying several physiological
responses. The NO produced by the inducible enzyme is a
cytotoxic molecule for tumor cells and invading
35 microorganisms. It also appears that the adverse effects of

excess NO production, in particular pathological vasodilation and tissue damage, may result largely from the effects of NO synthesized by the inducible NO synthase.

5 There is also a growing body of evidence that NO may be involved in the degeneration of cartilage which takes place in certain conditions such as arthritis and it is also known that NO synthesis is increased in rheumatoid arthritis. Accordingly, further conditions in which there is an
10 advantage in inhibiting NO production from L-arginine include autoimmune and/or inflammatory conditions affecting the joints, for example arthritis, inflammatory bowel disease, cardiovascular ischemia, diabetes, hyperalgesia (allodynia), cerebral ischemia (both focal
15 ischemia, thrombotic stroke and global ischemia, secondary to cardiac arrest), and other CNS disorders mediated by NO.

 Futher conditions in which there is an advantage in inhibiting NO production from L-arginine include systemic
20 hypotension associated with septic and/or toxic shock induced by a wide variety of agents; therapy with cytokines such as TNF, IL-1 and IL-2; and as an adjuvant to short term immunosuppression in transplant therapy.

25 Some of the NO synthase inhibitors proposed for therapeutic use so far, and in particular L-NMMA, are non-selective in that they inhibit both the constitutive and the inducible NO synthase. Use of such a non-selective NO synthase inhibitor requires that great care be taken in
30 order to avoid the potentially serious consequences of over-inhibition of the constitutive NO-synthase including hypertension and possible thrombosis and tissue damage. In particular, in the case of the therapeutic use of L-NMMA for the treatment of toxic shock it has been recommended that
35 the patient must be subject to continuous blood pressure

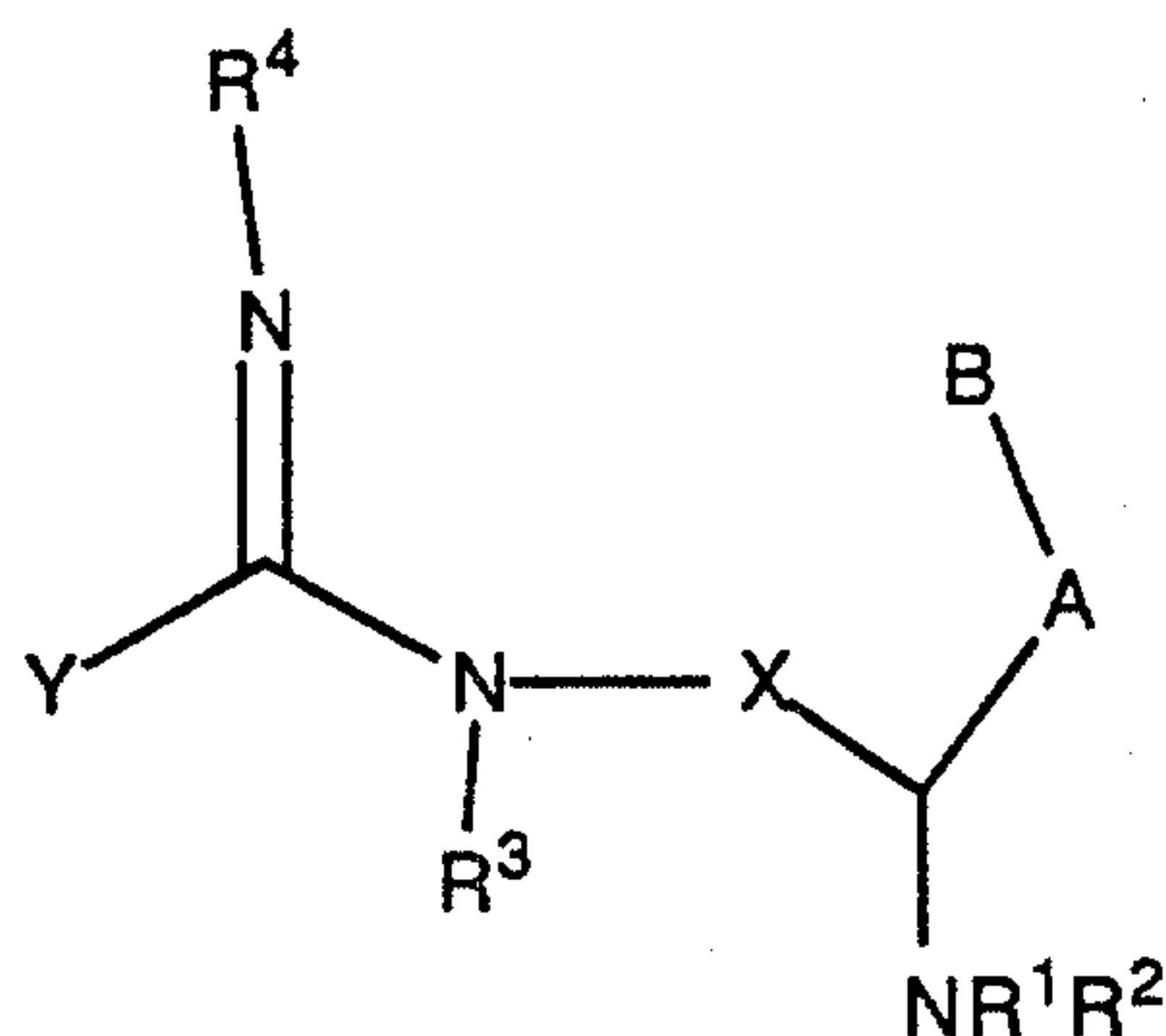
monitoring throughout the treatment. Thus, while non-selective NO synthase inhibitors have therapeutic utility provided that appropriate precautions are taken, NO synthase inhibitors which are selective in the sense that they
 5 inhibit the inducible NO synthase to a considerably greater extent than the constitutive isoforms of NO synthase would be of even greater therapeutic benefit and easier to use.

WO94/12165, WO94/14780, WO93/13055, EP0446699A1 and
 10 U.S. Patent No. 5,132,453 disclose compounds that inhibit nitric oxide synthesis and preferentially inhibit the inducible isoform of nitric oxide synthase.

15

Summary of the Invention

In accordance with the present invention novel amino glycol derivatives of L-N⁶-(1-iminoethyl)lysine derivatives
 20 are provided. These novel inhibitor compounds can be represented by the following chemical formula. A compound or a pharmaceutically acceptable salt, prodrug or ester thereof having the formula:



25

Y is a hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, alicyclic hydrocarbon radical, amino, heterocyclyl radical

in which 1 to about 4 heteroatoms are independently selected from oxygen, nitrogen and sulfur, wherein all said radicals may optionally be substituted with hydrogen, cyano, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical,
10 $(CH_2)_m Q (CH_2)_n$, where $m = 1-3$, $n = 1-3$, and Q is sulfur, sulfinyl, sulfonyl or oxygen, C=O, lower alkynyl radical, aromatic hydrocarbon radical, alicyclic hydrocarbon radical or heterocyclyl radicals in which 1 to about 4 heteroatoms are independently selected from oxygen, nitrogen and sulfur,
15 wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

20

A is a lower alkyl radical, lower alkenyl radical, lower alkynyl radical, alicyclic hydrocarbon radical, C=O, aromatic hydrocarbon radical or heterocyclyl radical in which 1 to about 4 heteroatoms are independently
25 selected from oxygen, nitrogen and sulfur, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkoxycarbonyl, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylethyl, sulfonylethylaryl, sulfonylethyl, halogen,
30 aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B can be hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, lower alkoxy radical,

35

hydroxy, alkoxycarbonyl, alkylaryloxy, thiol, lower
thioalkoxy, lower thioalkylaryloxy, thioaryloxy,
sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl,
sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, aromatic
5 hydrocarbon radical, alicyclic hydrocarbon radical, or
heterocyclyl radical in which 1 to about 4 heteroatoms are
independently selected from oxygen, nitrogen and sulfur
wherein all said radicals are optionally substituted with
hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen,
10 aromatic hydrocarbon radicals, or alicyclic hydrocarbon
radical, or

B can be $C(=O)OR^5$, $C(=O)NR^5R^6$, $P(=O)(OR^5)(OR^6)$, $NHOH$,
 $N(OH)C(=O)NR^5R^6$, $NR^5C(=O)NR^6R^7$, $NR^5C(=O)N(OH)R^6$, $C(=O)NHOH$,

15 where

R^5 is hydrogen, lower alkyl radical, aromatic hydrocarbon
radical, or alicyclic hydrocarbon radical wherein all said
radicals are optional substituted with lower alkyl, lower
20 alkenyl;

R^6 is hydrogen, lower alkyl radical, aromatic hydrocarbon
radical, or alicyclic hydrocarbon radical wherein all said
radicals are optional substituted with lower alkyl, lower
25 alkenyl; and

R^7 is hydrogen, lower alkyl radical, aromatic hydrocarbon
radical, or alicyclic hydrocarbon radical wherein all said
radicals are optional substituted with lower alkyl, lower
30 alkenyl;

with the proviso that when A is $C=O$, B may not be
hydroxy or alkoxy.

(I)

A is preferably lower alkyl which is substituted as indicated above.

In another broad aspect, the present invention is
5 directed to inhibiting nitric oxide synthesis in a subject
in need of such inhibition or treatment by administering a
compound of Formula (I) which preferentially inhibits the
inducible isoform of nitric oxide synthase over the
constitutive isoform of nitric oxide synthase, in a nitric
10 oxide synthesis inhibiting amount to such subject.

The invention further relates to a pharmaceutical
composition comprising a compound from Formula (I).

Compounds and compositions defined above have
15 usefulness as inhibitors of nitric oxide synthase. These
compounds also preferentially inhibit the inducible form
over the constitutive form by at least 3 fold.

Conditions in which there is an advantage in inhibiting
20 NO production from L-arginine include systemic hypotension
associated with septic and/or toxic shock induced by a wide
variety of agents; therapy with cytokines such as TNF, IL-1
and IL-2; and as an adjuvant to short term immunosuppression
in transplant therapy. Further conditions in which there is
25 an advantage in inhibiting NO production from L-arginine
include autoimmune diseases and/or inflammatory conditions
such as those affecting the joints, for example arthritis or
inflammatory bowel disease, cardiovascular ischemia,
diabetes, cerebral ischemia and other CNS disorders mediated
30 by NO.

A preferred embodiment of the present invention is a
compound of the formula (I) wherein

Y is hydrogen or lower alkylene
35 X is lower alkylene from 3-5 carbon

2184691

8

R^1 , R^2 , R^3 , and R^4 are independently selected from the group consisting of hydrogen or lower alkyl

A is lower alkylene from 2-4 carbons substituted with hydroxyl

5 B is hydroxyl.

It is preferred that Y is methyl, X is preferably butylene, R^1 , R^2 , R^3 , and R^4 are preferably hydrogen, A is preferably ethylene or isopropylene substituted with
10 hydroxyl and B is preferably hydroxyl (OH).

The present invention includes compounds of formula (I) in the form of salts, in particular acid addition salts.
15 Suitable salts include those formed with both organic and inorganic acids. Such acid addition salts will normally be pharmaceutically acceptable although salts of non-pharmaceutically acceptable salts may be of utility in the preparation and purification of the compound in question.
20 Thus, preferred salts include those formed from hydrochloric, hydrobromic, sulfuric, citric, tartaric, phosphoric, lactic, acetic, succinic, fumaric, maleic, methanesulfonic, ethanesulfonic, p-toluenesulfonic, benzenesulfonic and the like. (See, for example, S. M.
25 Berge et al., *Pharmaceutical Salts*, *J. Pharm. Sci.*, **1977**, 66, 1-19.) Salts of the compounds of formula (I) can be made by reacting the appropriate compound in the form of the free base with the appropriate acid.

30 While it may be possible for the compounds of formula (I) to be administered as the raw chemical, it is preferable to present them as a pharmaceutical formulation. According to a further aspect, the present invention provides a pharmaceutical formulation comprising a compound of formula
35 (I) or a pharmaceutically acceptable salt or solvate

thereof, together with one or more pharmaceutically acceptable carriers thereof and optionally one or more other therapeutic ingredients. The carrier(s) must be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

The formulations include those suitable for oral, parenteral (including subcutaneous, intradermal, intramuscular, intravenous and intraarticular), rectal and topical (including dermal, buccal, sublingual and intraocular) administration although the most suitable route may depend upon for example the condition and disorder of the recipient. The formulations may conveniently be presented in unit dosage form and may be prepared by any of the methods well known in the art of pharmacy. All methods include the step of bringing into association a compound of formula (I) or a pharmaceutically acceptable salt or solvate thereof ("active ingredient") with the carrier which constitutes one or more accessory ingredients. In general, the formulations are prepared by uniformly and intimately bringing into association the active ingredient with liquid carriers or finely divided solid carriers or both and then, if necessary, shaping the product into the desired formulation.

Formulations of the present invention suitable for oral administration may be presented as discrete units such as capsules, cachets or tablets each containing a predetermined amount of the active ingredient; as a powder or granules; as a solution or a suspension in an aqueous liquid or a non-aqueous liquid; or as an oil-in-water liquid emulsion or a water-in-oil liquid emulsion. The active ingredient may also be presented as a bolus, electuary or paste.

A tablet may be made by compression or moulding, optionally with one or more accessory ingredients. Compressed tablets may be prepared by compressing in a suitable machine the active ingredient in a free-flowing form such as a powder or granules, optionally mixed with a binder, lubricant, inert diluent, lubricating, surface active or dispersing agent. Moulded tablets may be made by moulding in a suitable machine a mixture of the powdered compound moistened with an inert liquid diluent. The tablets may optionally be coated or scored and may be formulated so as to provide slow or controlled release of the active ingredient therein.

Formulations for parenteral administration include aqueous and non-aqueous sterile injection solutions which may contain antioxidants, buffers, bacteriostats and solutes which render the formulation isotonic with the blood of the intended recipient; and aqueous and non-aqueous sterile suspensions which may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example sealed ampoules and vials, and may be stored in a freeze-dried (lyophilized) condition requiring only the addition of the sterile liquid carrier, for example, saline, water-for-injection, immediately prior to use. Extemporaneous injection solutions and suspensions may be prepared from sterile powders, granules and tablets of the kind previously described.

Formulations for rectal administration may be presented as a suppository with the usual carriers such as cocoa butter or polyethylene glycol.

Formulations for topical administration in the mouth, for example buccally or sublingually, include lozenges

comprising the active ingredient in a flavored basis such as sucrose and acacia or tragacanth, and pastilles comprising the active ingredient in a basis such as gelatin and glycerin or sucrose and acacia.

5

Preferred unit dosage formulations are those containing an effective dose, as hereinbelow recited, or an appropriate fraction thereof, of the active ingredient.

10

It should be understood that in addition to the ingredients particularly mentioned above, the formulations of this invention may include other agents conventional in the art having regard to the type of formulation in question, for example those suitable for oral administration may include flavoring agents.

15

The compounds of the invention may be administered orally or via injection at a dose of from 0.001 to 2500 mg/kg per day. The dose range for adult humans is generally from 0.005 mg to 10 g/day. Tablets or other forms of presentation provided in discrete units may conveniently contain an amount of compound of the invention which is effective at such dosage or as a multiple of the same, for instance, units containing 5 mg to 500 mg, usually around 10 mg to 200 mg.

20

25

The compounds of formula (I) are preferably administered orally or by injection (intravenous or subcutaneous). The precise amount of compound administered to a patient will be the responsibility of the attendant physician. However, the dose employed will depend on a number of factors, including the age and sex of the patient, the precise disorder being treated, and its severity. Also, the route of administration may vary depending on the condition and its severity.

30

35

2184691

12

As utilized herein, the term "lower alkyl", alone or in combination, means an acyclic alkyl radical containing from 1 to about 10, preferably from 1 to about 8 carbon atoms and more preferably 1 to about 6 carbon atoms. Examples of such radicals include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, pentyl, iso-amyl, hexyl, octyl and the like.

The term "lower alkenyl" refers to an unsaturated acyclic hydrocarbon radical in so much as it contains at least one double bond. Such radicals containing from about 2 to about 10 carbon atoms, preferably from about 2 to about 8 carbon atoms and more preferably 2 to about 6 carbon atoms. Examples of suitable alkenyl radicals include propylenyl, buten-1-yl, isobutenyl, pentenylen-1-yl, 2-2-methylbuten-1-yl, 3-methylbuten-1-yl, hexen-1-yl, hepten-1-yl, and octen-1-yl, and the like.

The term "lower alkynyl" refers to an unsaturated acyclic hydrocarbon radical in so much as it contains one or more triple bonds, such radicals containing about 2 to about 10 carbon atoms, preferably having from about 2 to about 8 carbon atoms and more preferably having 2 to about 6 carbon atoms. Examples of suitable alkynyl radicals include ethynyl, propynyl, butyn-1-yl, butyn-2-yl, pentyn-1-yl, pentyn-2-yl, 3-methylbutyn-1-yl, hexyn-1-yl, hexyn-2-yl, hexyn-3-yl, 3,3-dimethylbutyn-1-yl radicals and the like.

The term "alicyclic hydrocarbon" or "cycloalkyl" means a aliphatic radical in a ring with 3 to about 10 carbon atoms, and preferably from 3 to about 6 carbon atoms. Examples of suitable alicyclic radicals include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclohexenyl and the like.

The term "aromatic hydrocarbon radical" means 4 to about 16 carbon atoms, preferably 6 to about 12 carbon atoms,

more preferably 6 to about 10 carbon atoms. Examples of suitable aromatic hydrocarbon radicals include phenyl, naphthyl, and the like.

5 The term "aryl" as used herein means 5- and 6-membered single-aromatic radicals which may include from zero to four heteroatoms. Representative aryls include phenyl, thienyl, furanyl, pyridinyl, (is)oxazolyl and the like.

The term DCM means dichloromethane.

The term DEAD means diethyl azodicarboxylate.

10 The term DIBAL-H means diisobutylaluminum hydride.

The term DMAP means dimethylaminopyridine.

The term DMSO means dimethylsulfoxide.

The term EDC means 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride.

15 The term "heterocyclyl radical" means a saturated or unsaturated cyclic hydrocarbon radical including aromatic systems with 4 to about 10 carbon atoms, preferably about 5 to about 6; wherein 1 to about 4 carbon atoms are replaced by nitrogen, oxygen or sulfur. The "heterocyclic radical" may be fused to an aromatic hydrocarbon radical. Suitable
20 examples include pyrrolyl, pyridinyl, pyrazolyl, triazolyl, pyrimidinyl, pyridazinyl, oxazolyl, isoxazolyl, thiazolyl, imidazolyl, indolyl, thienyl, furanyl, tetrazolyl, 2-pyrrolinyl, 3-pyrrolinyl, pyrrolidinyl, 1,3-dioxolanyl, 2-imidazoninyl, imidazolidinyl, 2-pyrazolinyl, pyrazolidinyl, isoxazolyl, isothiazolyl, oxadiazolyl, triazolyl, thiadiazolyl, 2H-pyranyl, 4H-pyranyl, piperidinyl, 1,4-dioxanyl, morpholinyl, 1,4-dithianyl, thiomorpholinyl, pyrazinyl, piperazinyl, triazinyl, 1,3,5-trithianyl,
25 benzo(b)thiophenyl, benzimidazolyl, quinolinyl, and the like.

The term HOBt means N-hydroxybenzotriazole.

35 The term "lower alkoxy", alone or in combination, means an alkyl ether radical wherein the term alkyl is as defined above and most preferably containing 1 to about 4 carbon

atoms. Examples of suitable alkyl ether radicals include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, isobutoxy, sec-butoxy, tert-butoxy and the like.

5 The term "lower thioalkoxy", alone or in combination, means an alkyl thioether radical wherein the term alkyl is as defined above and most preferably containing 1 to about 4 carbon atoms. Examples of suitable alkyl thioether radicals include thiomethoxy, thioethoxy, thio-n-propoxy, thio-i-propoxy, thio-n-butoxy, thio-iso-butoxy, thio-sec-butoxy,
10 thio-tert-butoxy and the like.

The term alkoxycarbonyl as used herein means an alkoxy group, as defined above, having a carbonyl (C=O) group attached.

15 The term "halogen" means fluorine, chlorine, bromine or iodine.

The term mcpba means m-chloroperbenzoic acid.

The term NMM means N-methylmorpholine.

The term NMMO means 4-methylmorpholine N-oxide.

20 The term "prodrug" refers to a compound that is made more active *in vivo*.

The term sulfinyl means SO.

The term sulfonyl means SO₂.

The term TEA means triethylamine.

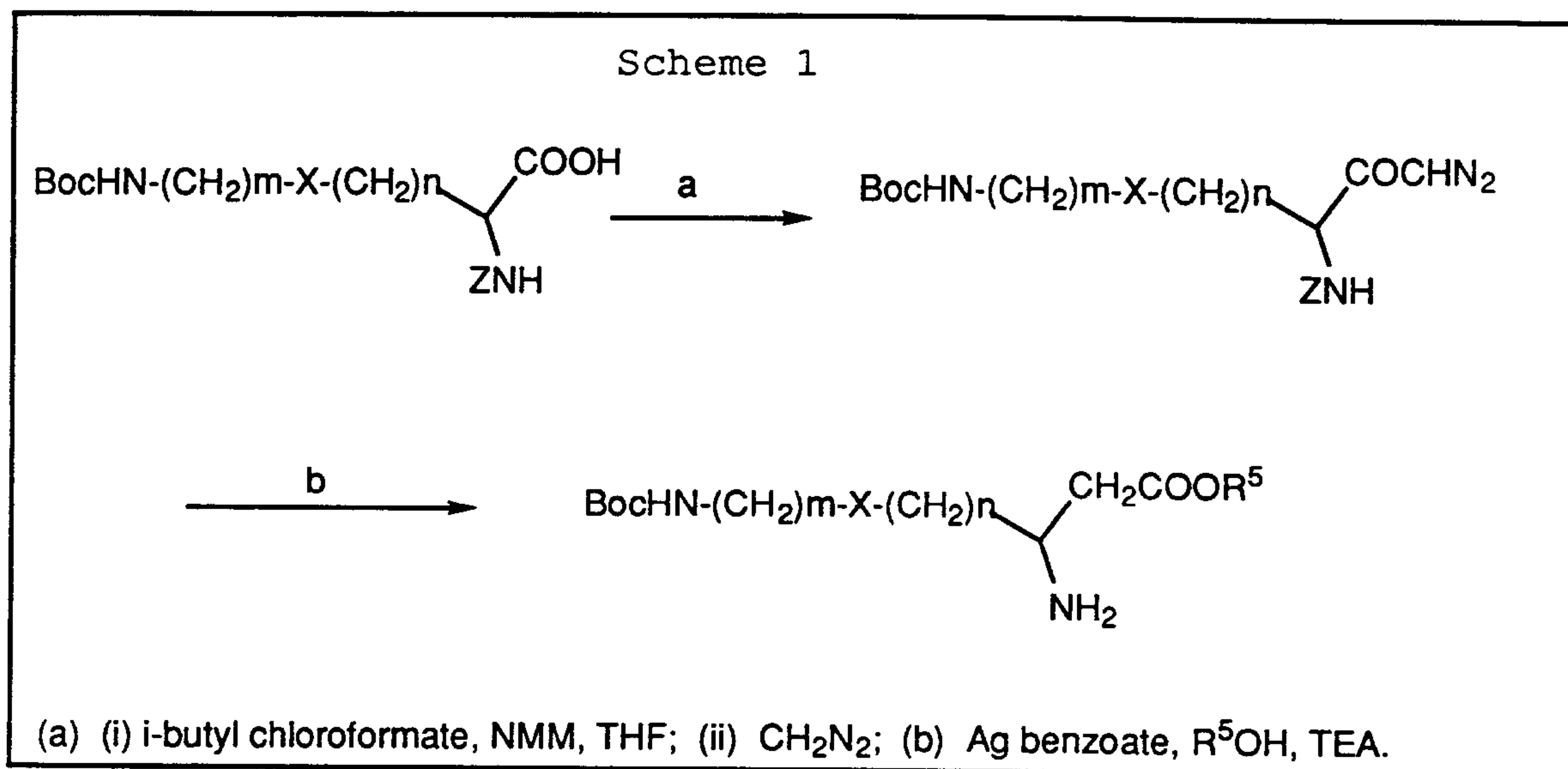
The term TMSN₃ means azidotrimethylsilane.

25 As used herein, reference to "treatment" of a patient is intended to include prophylaxis.

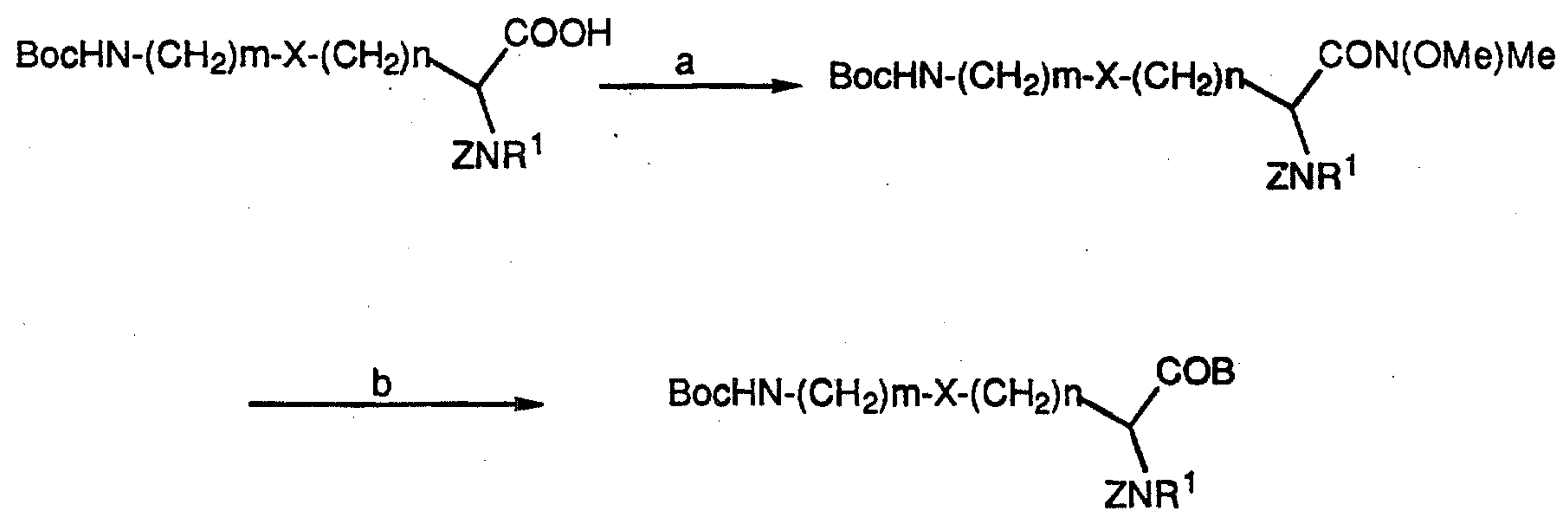
30 Compounds of the present invention can exist in geometric or stereoisomeric forms. The present invention contemplates all such compounds, including cis- and trans-geometric isomers, E- and Z-geometric isomers, R- and S-enantiomers, diastereomers, d-isomers, l-isomers, the

racemic mixtures thereof and other mixtures thereof, as falling within the scope of the invention.

Disclosed are twenty eight general synthetic processes
5 useful in the preparation of the compounds of the present invention.

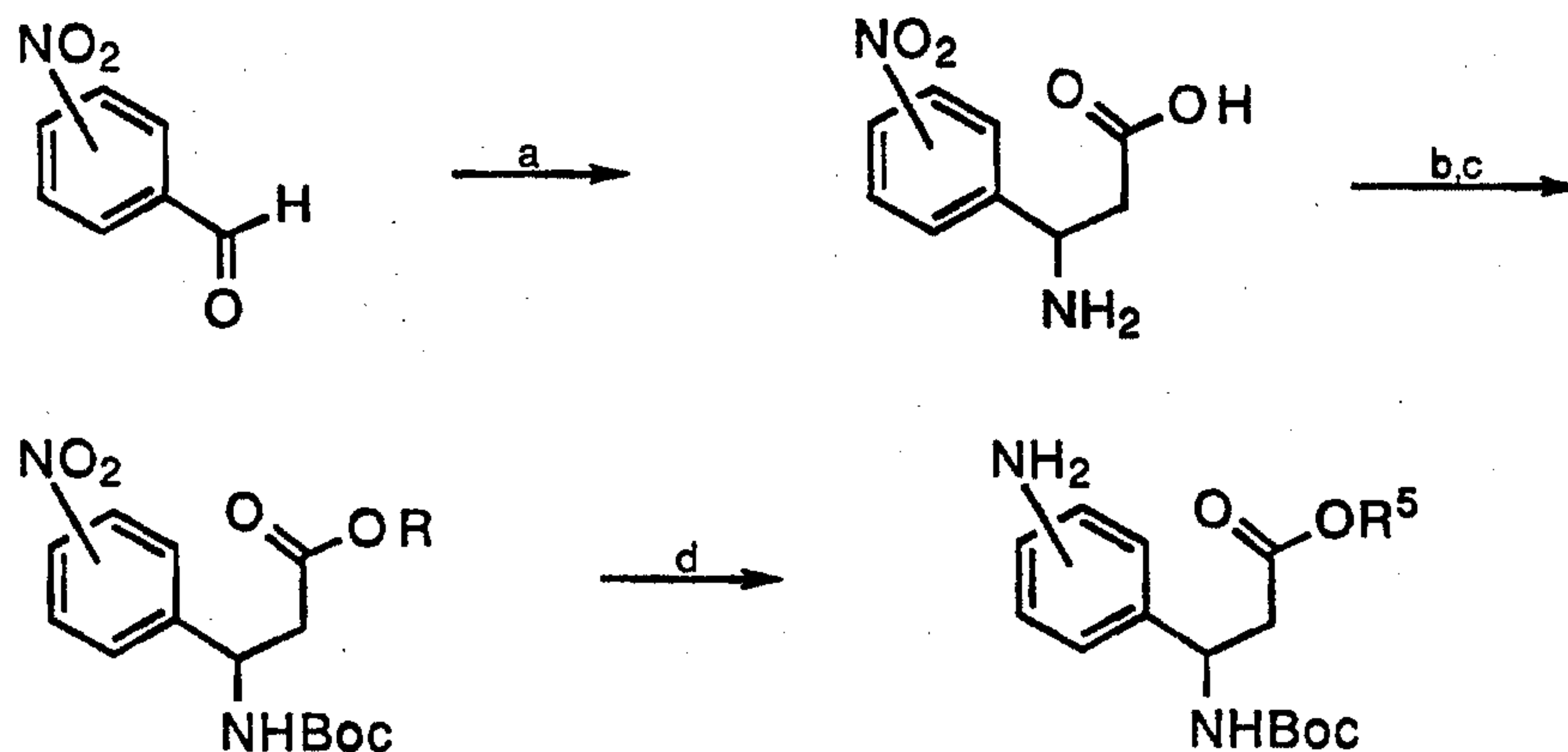


Scheme 2



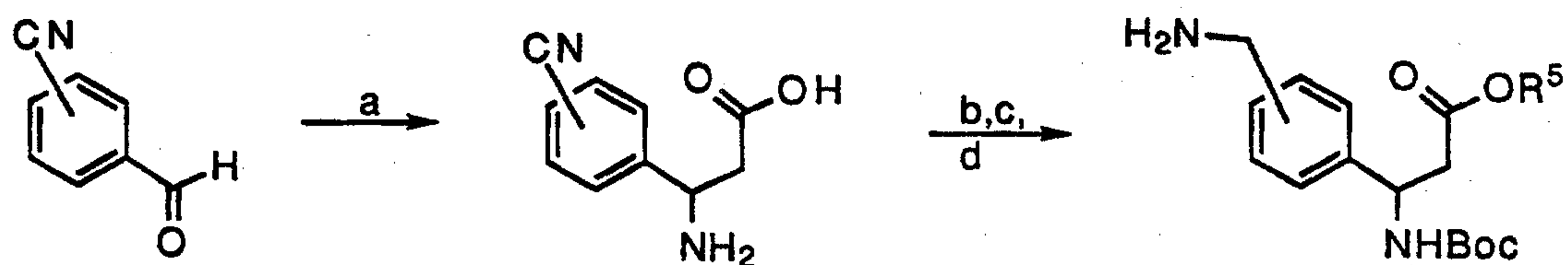
(a) N,O-Dimethylhydroxylamine HCl, EDC, HOBT, TEA, DMF; (b) B^*Li , THF.

Scheme 3



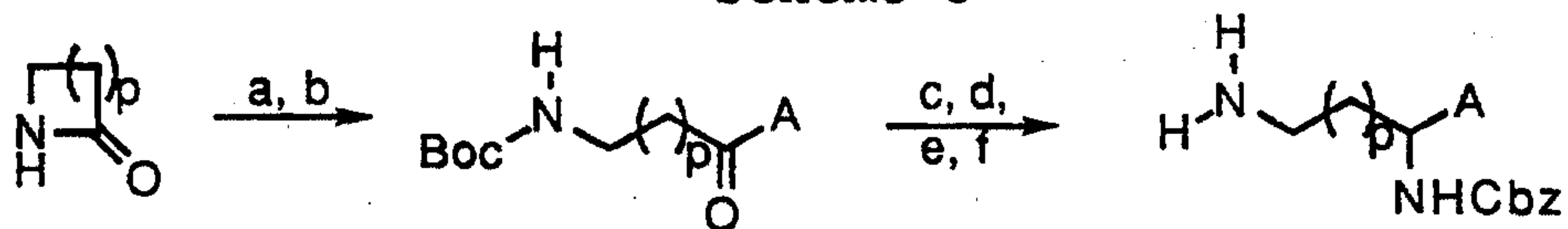
(a) ammonium acetate, malonic acid, acetic acid; (b) di-*t*-butyl dicarbonate, NaOH/dioxane; (c) NaHCO₃, DMF, R⁵I; (d) H₂ Pd/C.

Scheme 4



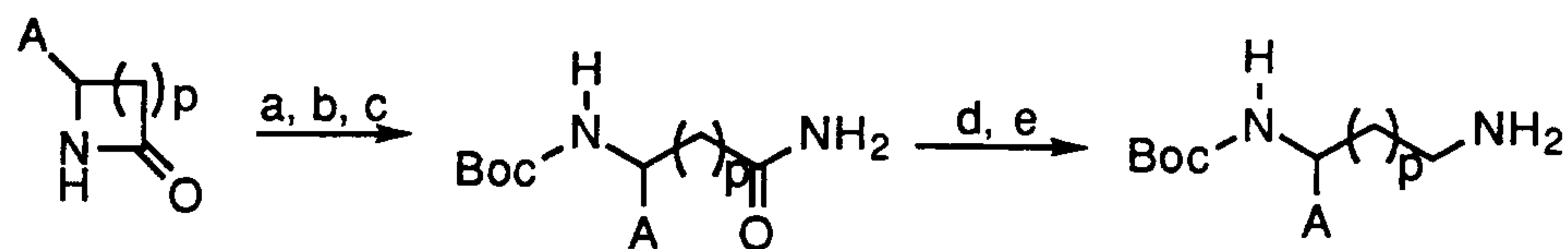
(a) ammonium acetate, malonic acid, acetic acid; (b) di-*t*-butyl dicarbonate, NaOH/dioxane; (c) NaHCO₃, DMF, R⁵I; (d) H₂ Pd/C.

Scheme 5



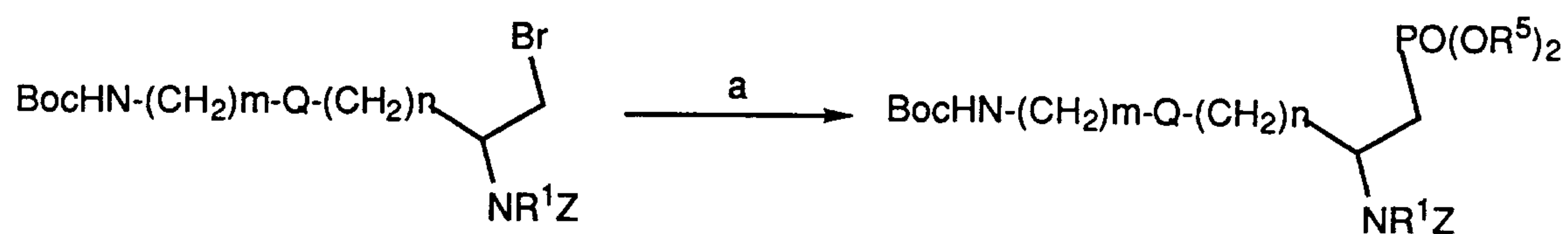
(a) di-*t*-butyl dicarbonate, DMAP, THF; (b) A*Li; (c) hydroxylamine hydrochloride; (d) H₂ Pd/C; (e) CbzCl; (f) HCl/dioxane.

Scheme 6



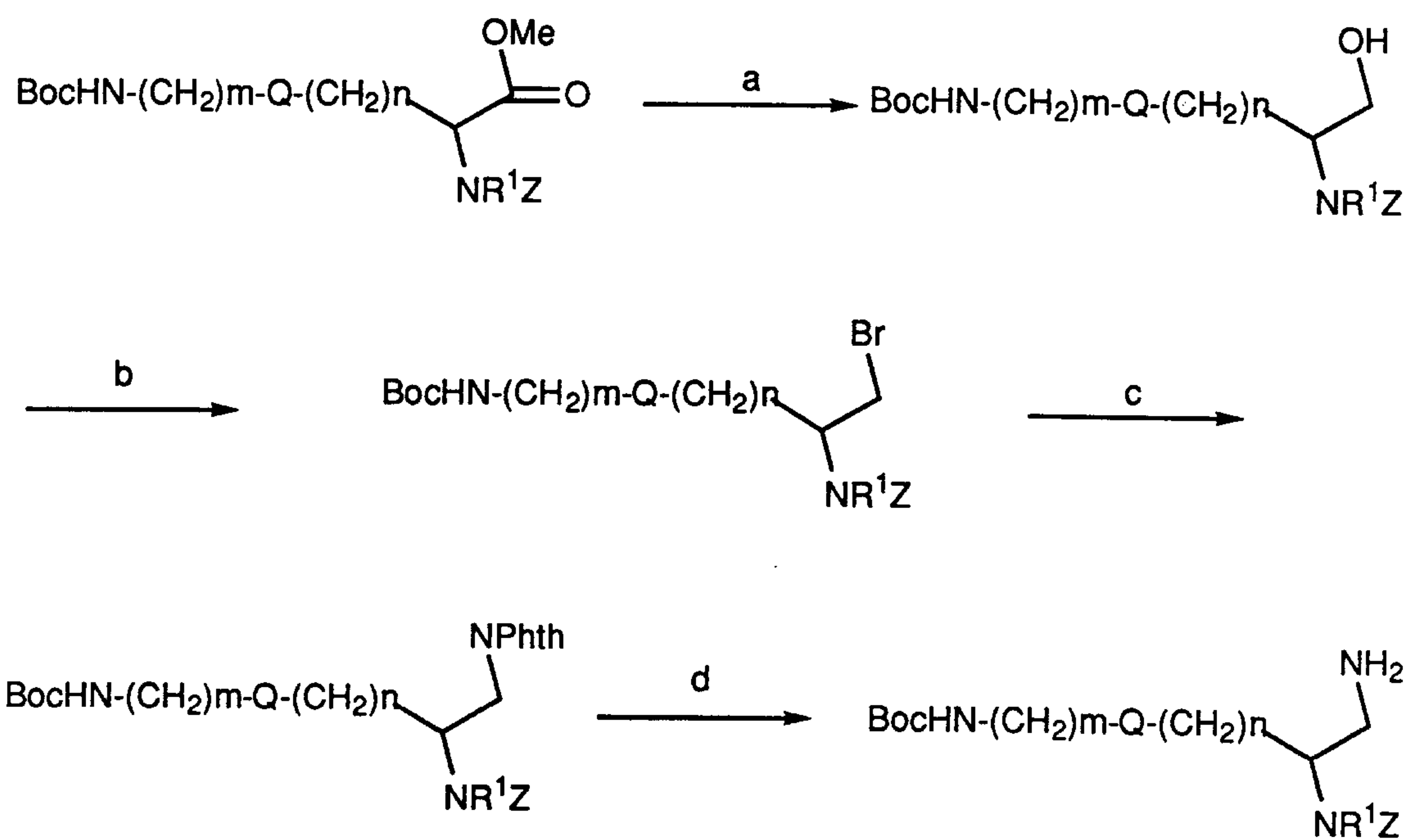
(a) di-t-butyl dicarbonate, DMAP, THF; (b) LiOH; (c) i-butyl chloroformate, ammonia
(d) trifluoroacetic anhydride, Et₃N (e) H₂/Pd.

Scheme 7



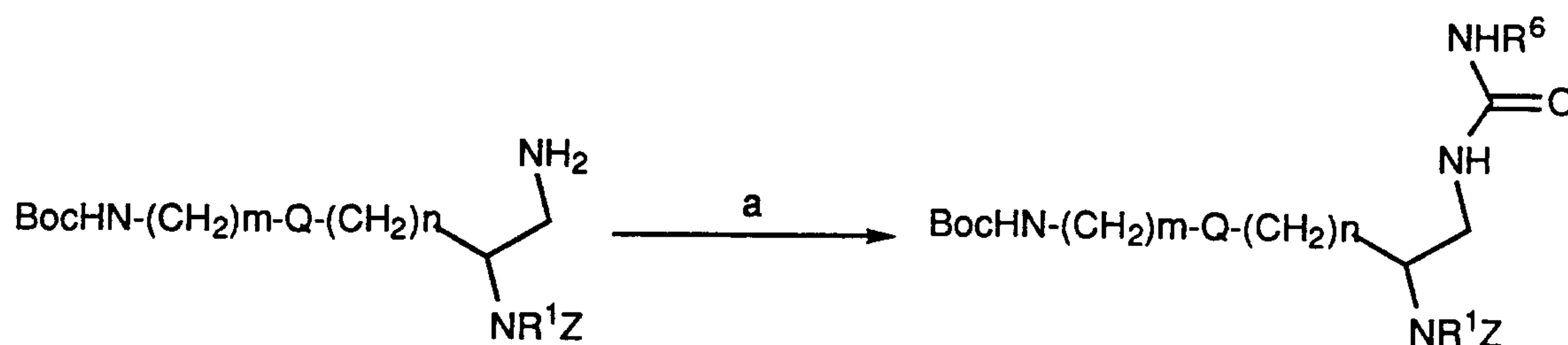
(a) P(OR⁵)₃.

Scheme 8



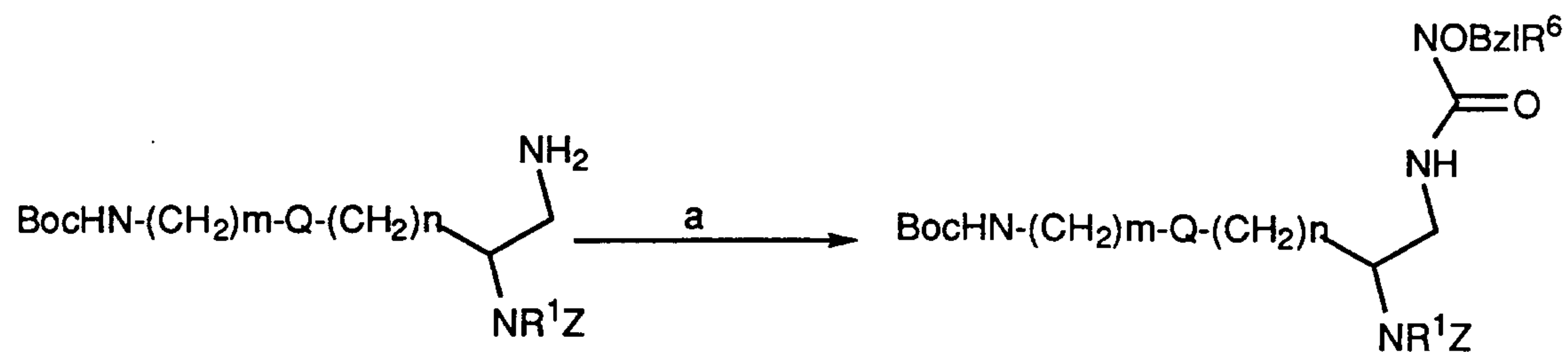
(a) DIBAL-H, toluene, -70°C , 1 h; (b) Ph_3PBr_2 , DMAc, 16 h; (c) K^+NPhth , THF; (d) NH_2NH_2 , EtOH.

Scheme 9



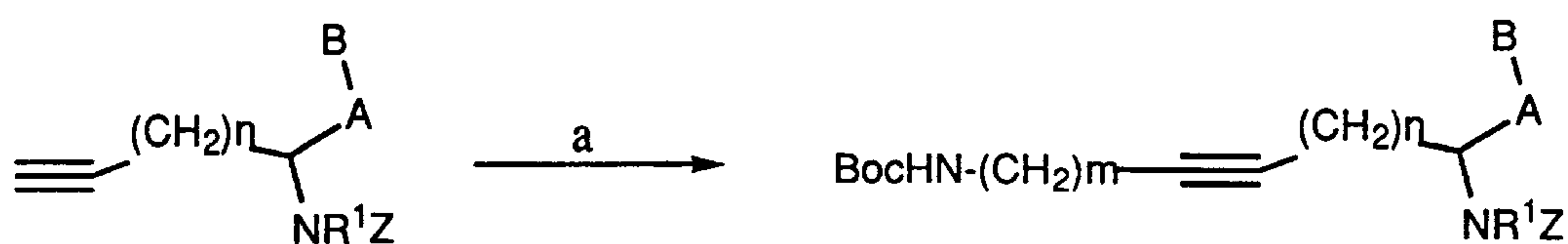
(a) $\text{O}=\text{C}=\text{NR}^6$, DCM.

Scheme 10



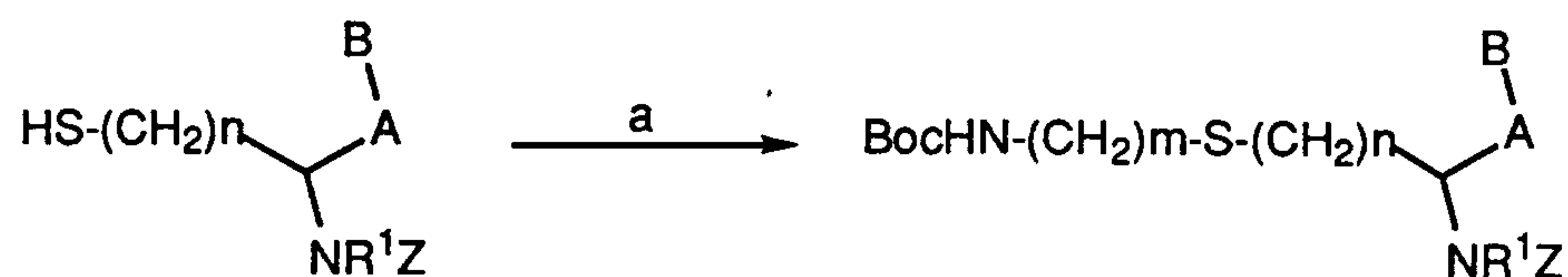
(a) carbonyldiimidazole, NHOBzIR^6 , DCM.

Scheme 11



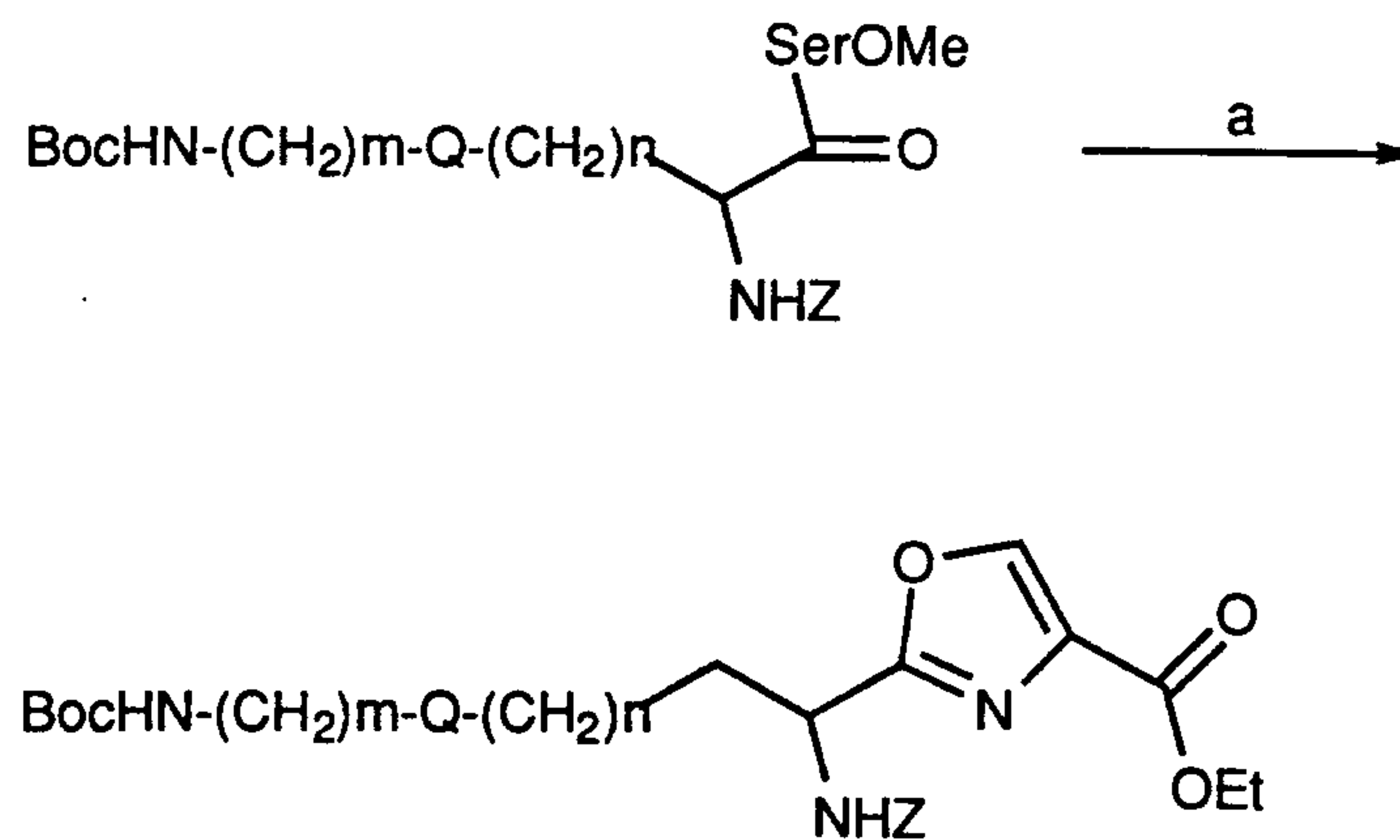
(a) $n\text{-BuLi}$, THF, $\text{BocNH}(\text{CH}_2)_m\text{Br}$.

Scheme 12

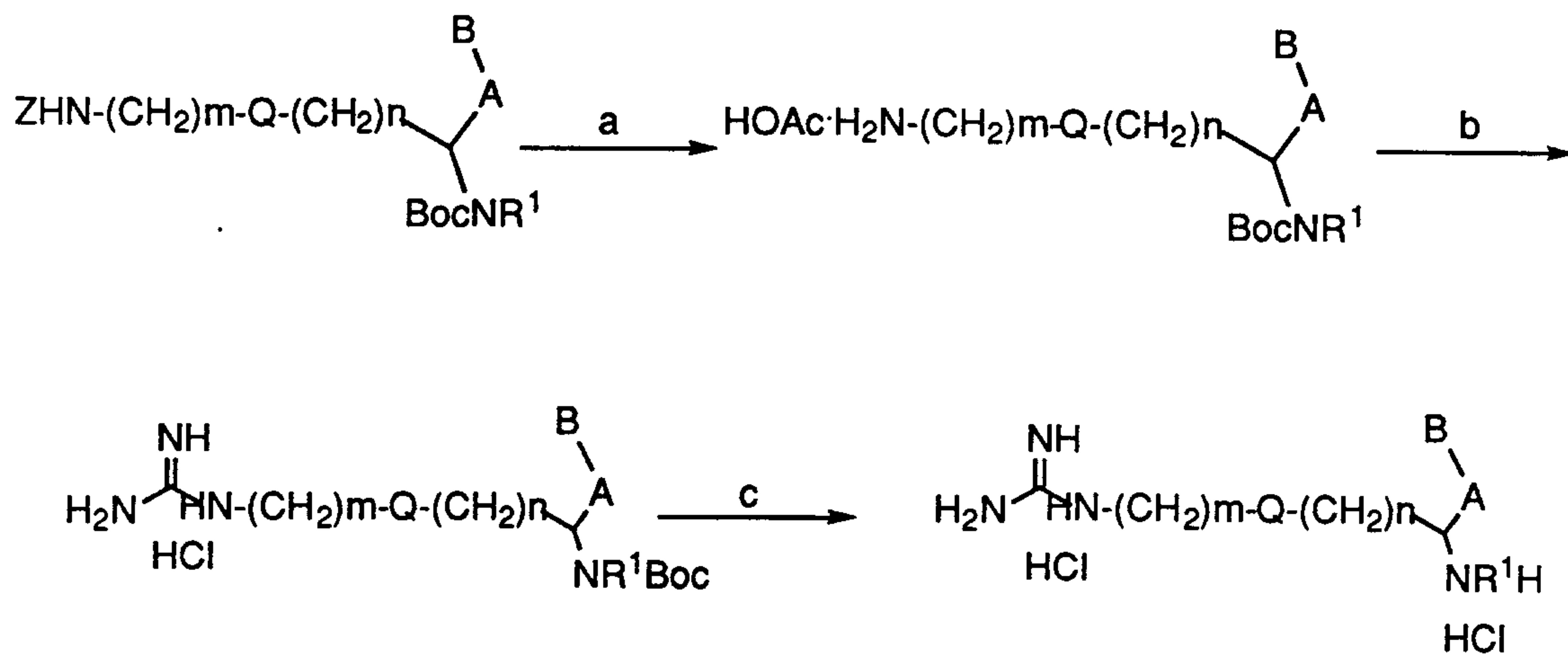


(a) NaOMe , THF, $\text{BocNH}(\text{CH}_2)_m\text{Br}$.

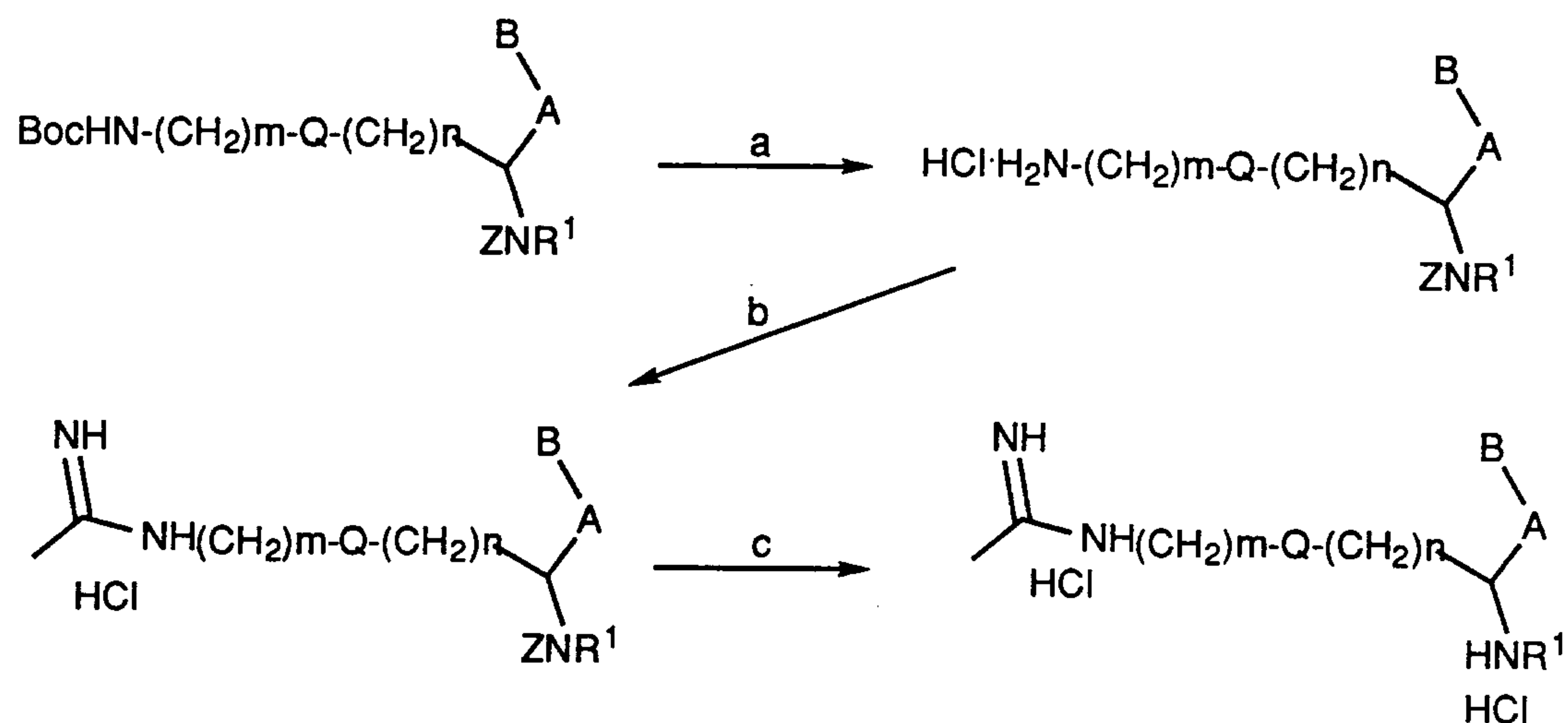
Scheme 13

(a) (i) Ph_3P , CBr_4 , (ii) CuBr_2 .

Scheme 14

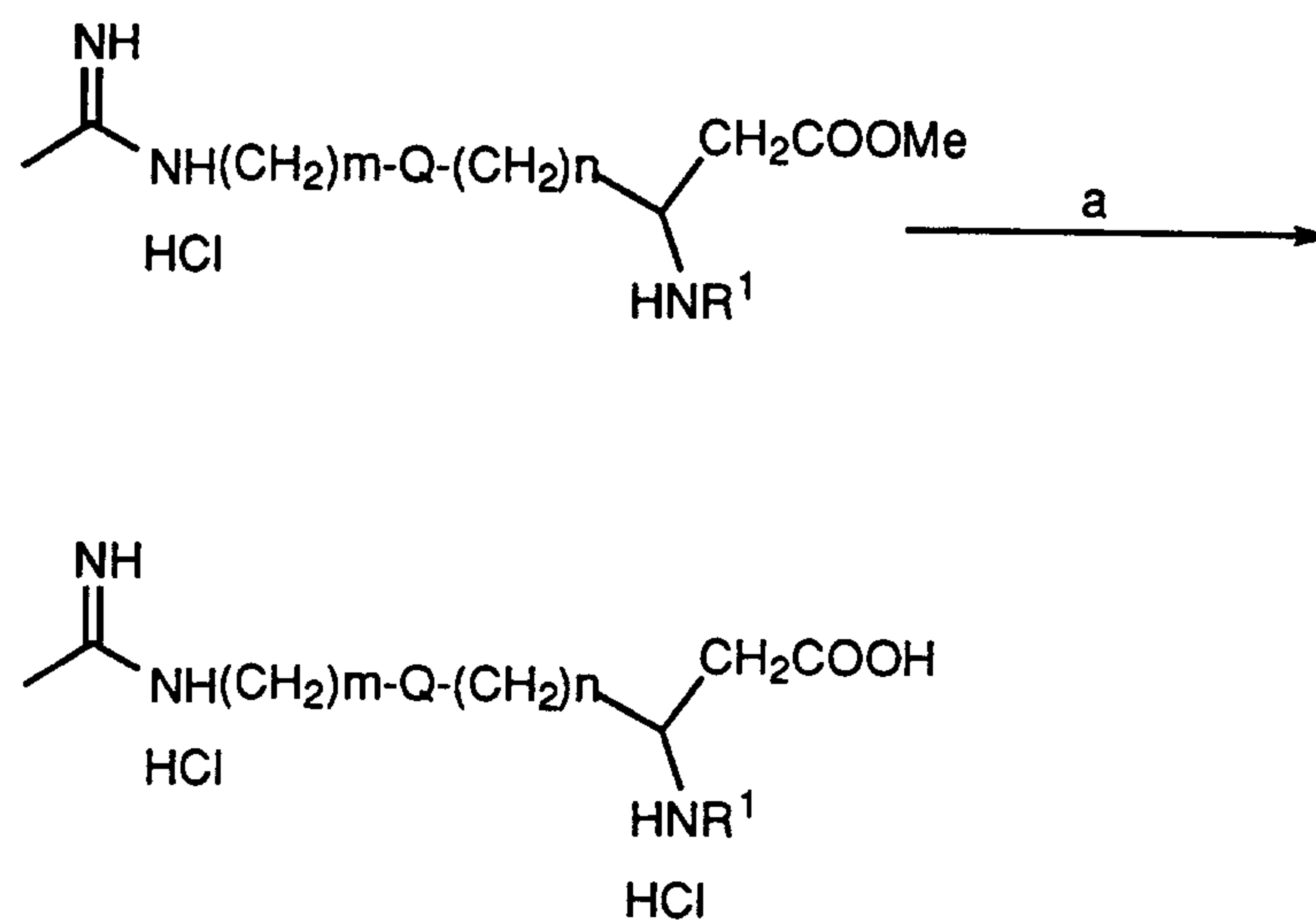
(a) H_2 , Pd black, EtOH/HOAc ; (b) (i) 3,5-dimethylpyrazole-1-carboxamide nitrate, NaOH ; (ii) 1N HCl ; (c) $\text{HCl}/\text{dioxane}$, HOAc .

Scheme 15



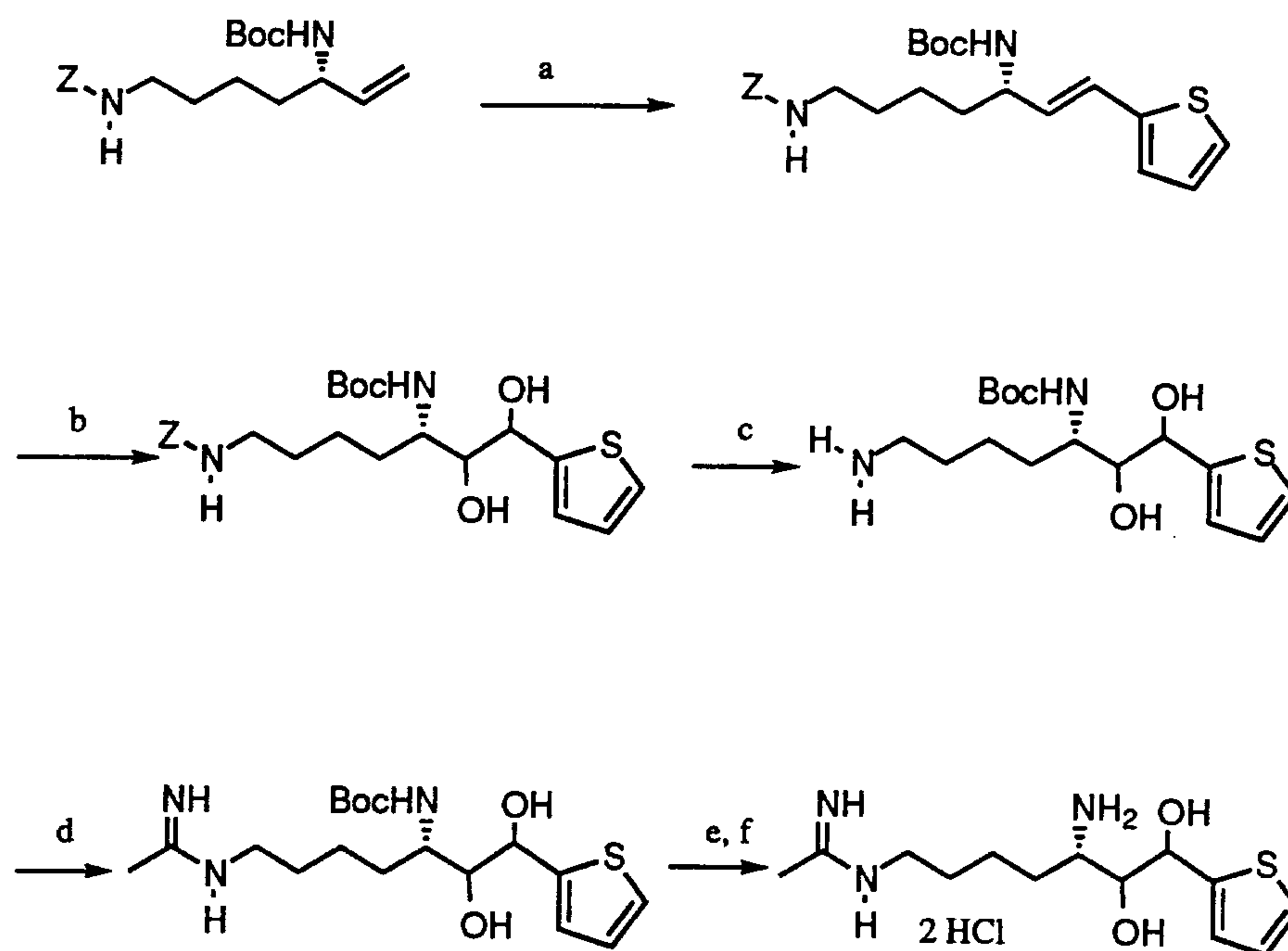
(a) HCl/dioxane, HOAc; (b) (i) methyl acetimidate, NaOH; (ii) 1 N HCl; (c) H_2 , Pd black, EtOH, HOAc.

Scheme 16

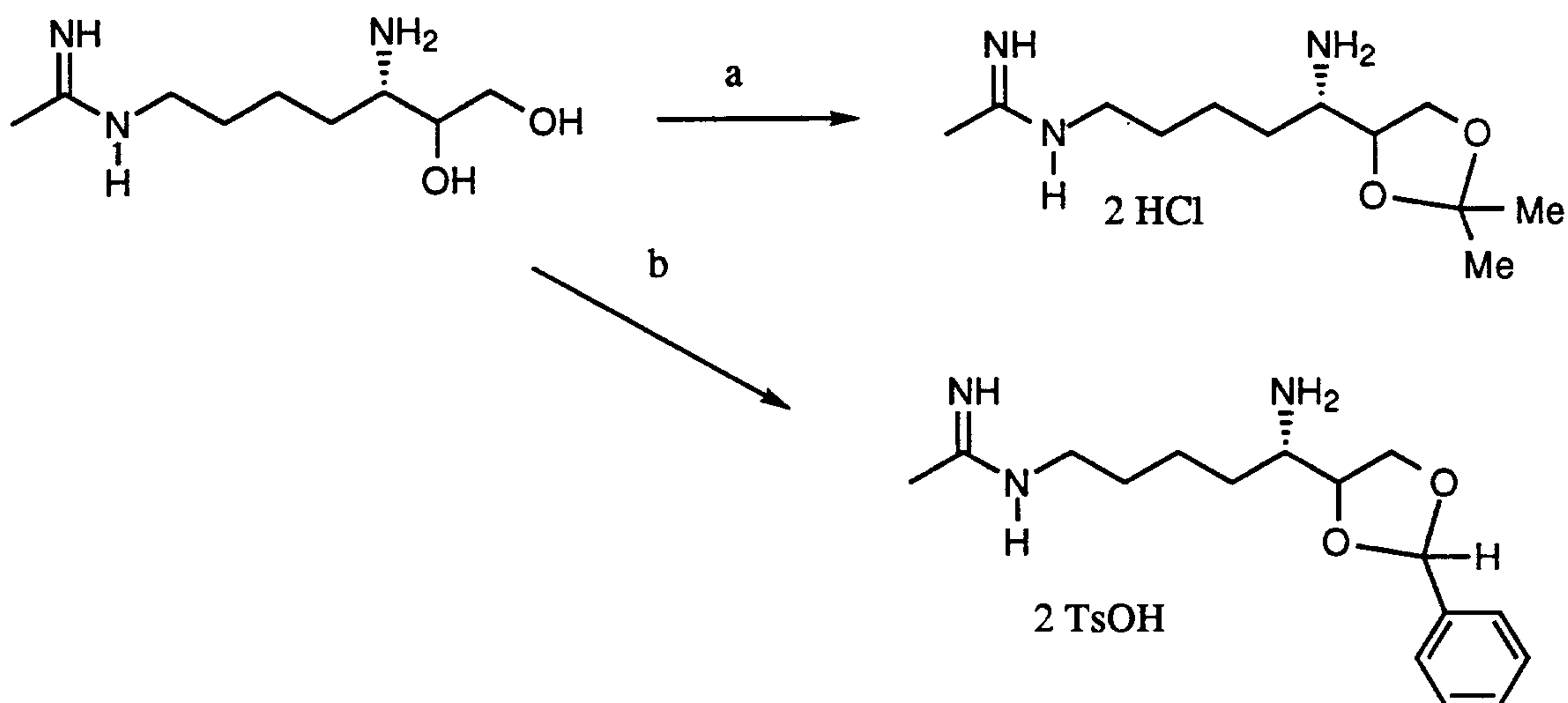


(a) 2 N HCl, Δ .

Scheme 17

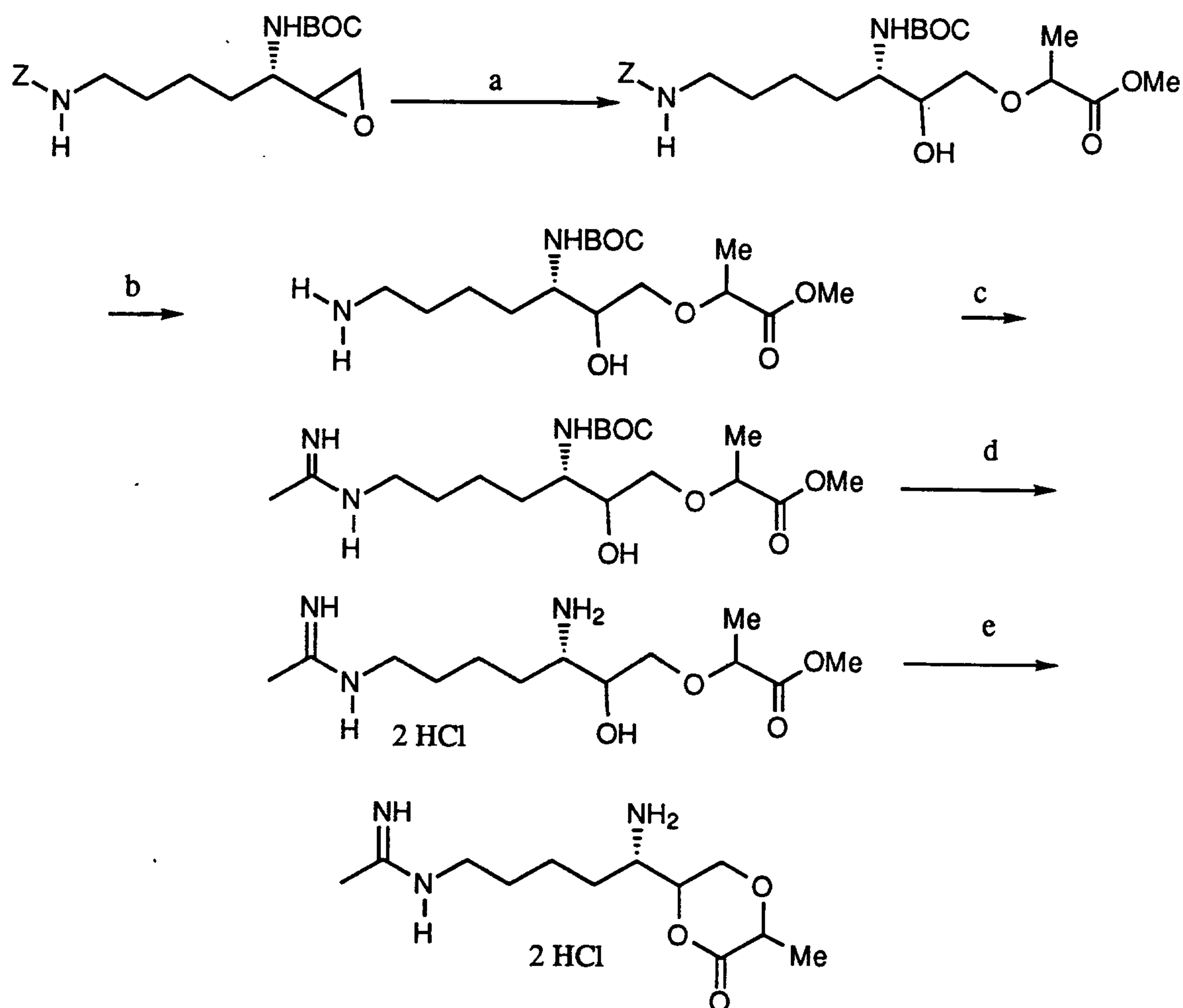


Scheme 19



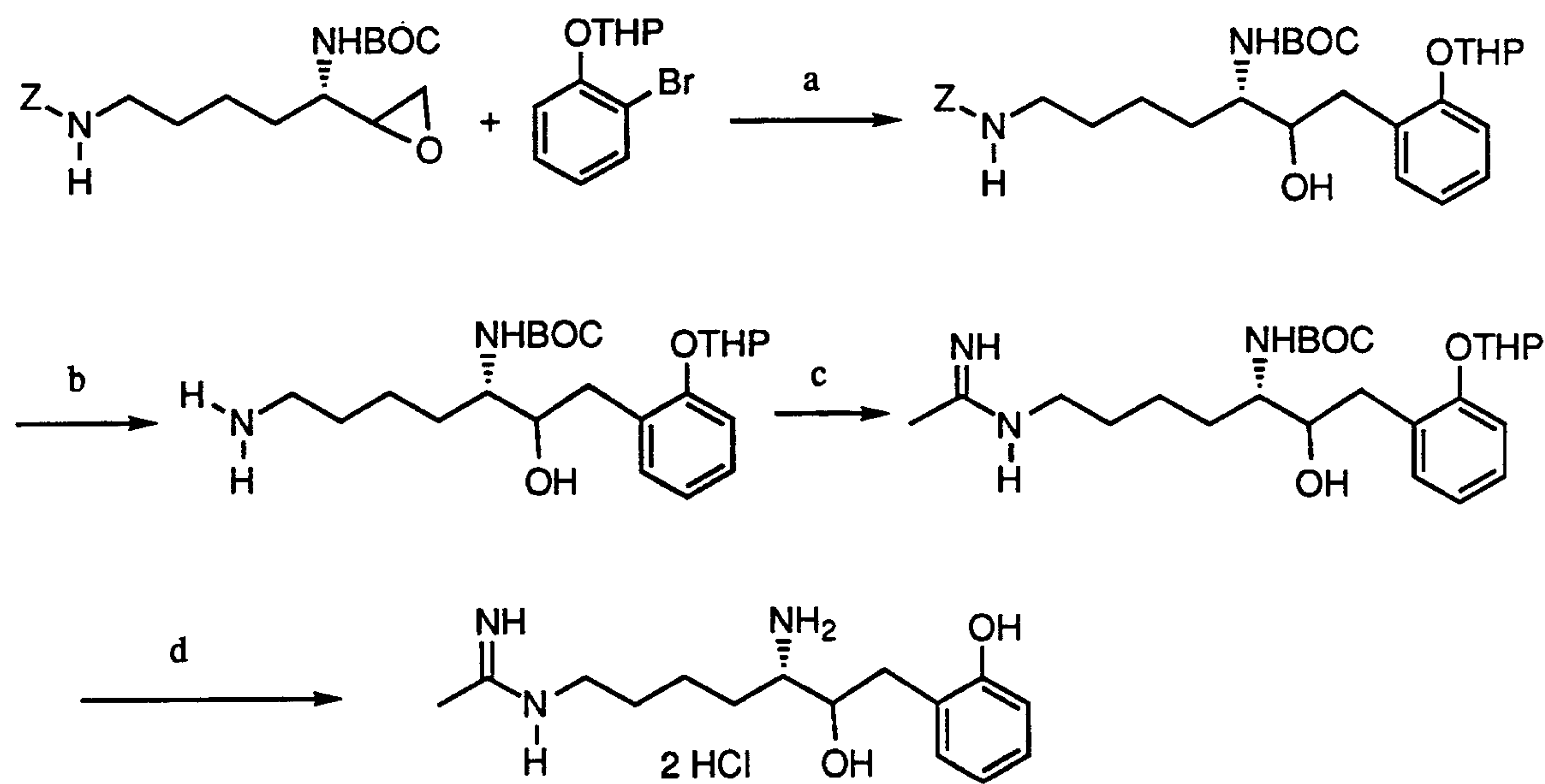
(a) 2,2-dimethoxypropane/DMF/HCl/Dioxane; (b) 1,1,1-trichloroethane/TsOH/benzaldehyde.

Scheme 20



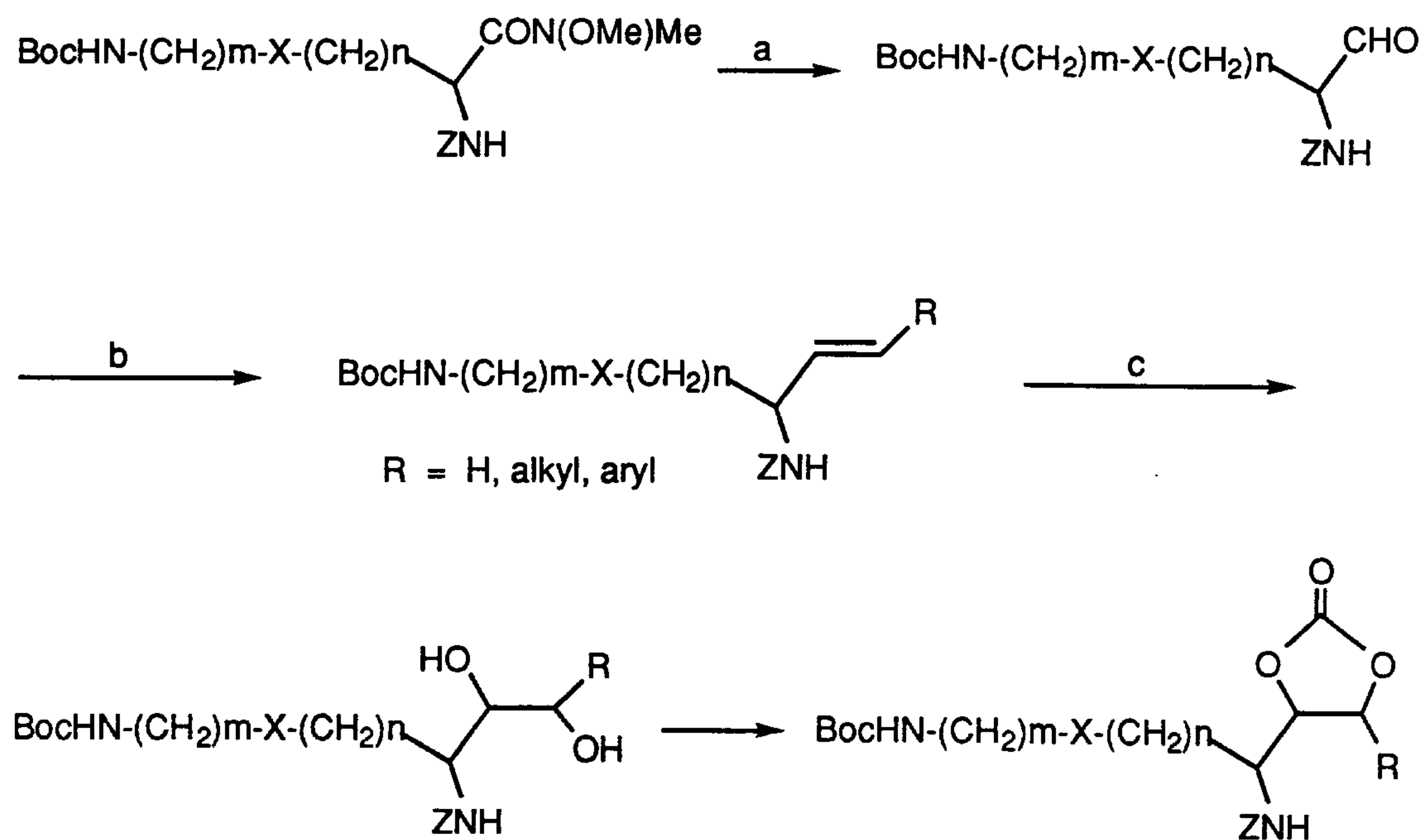
(a) NaH/DMF/ $ZnCl_2$ /THF/methyl lactate; (b) H_2 /Pd/AcOH; (c) ethyl acetimidate HCl/EtOH; (d) HCl/Dioxane/AcOH; (e) HCl/ H_2O .

Scheme 21



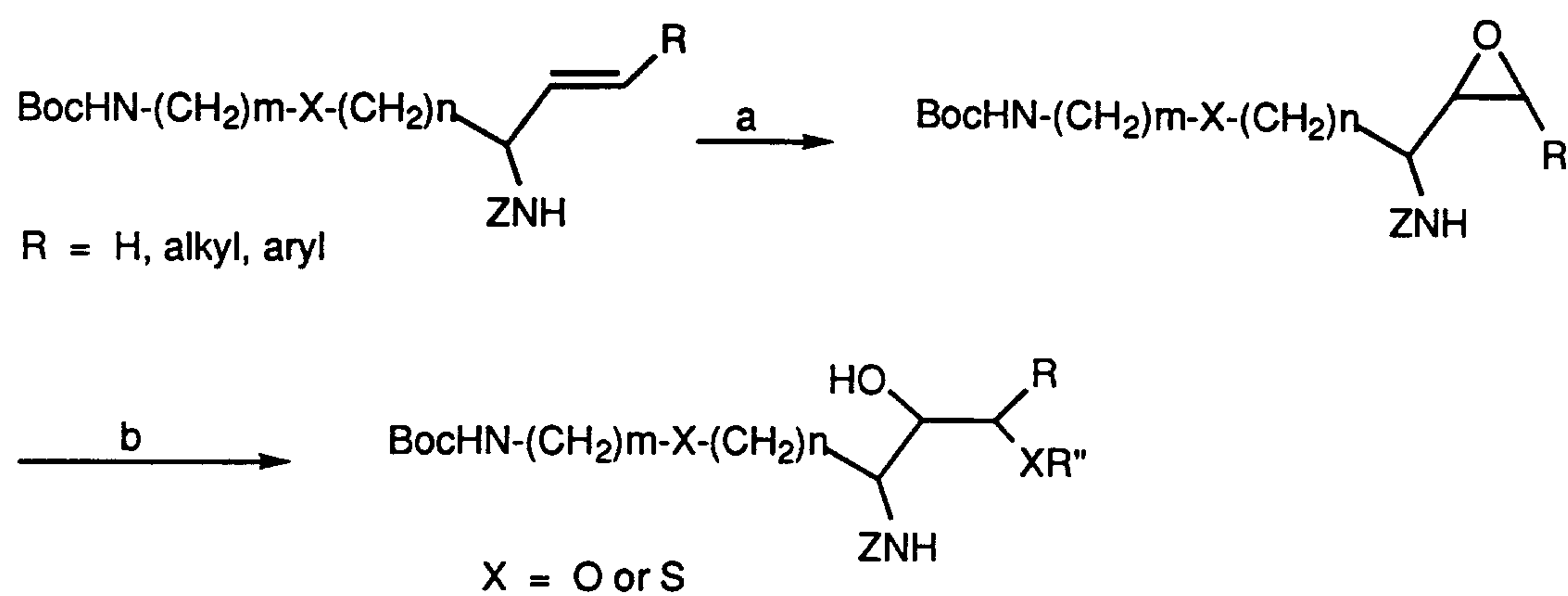
(a) n-BuLi/THF/-78 °C; (b) H₂/Pd/AcOH; (c) ethyl acetimidate HCl/EtOH;
(d) HCl/Dioxane/AcOH.

Scheme 22



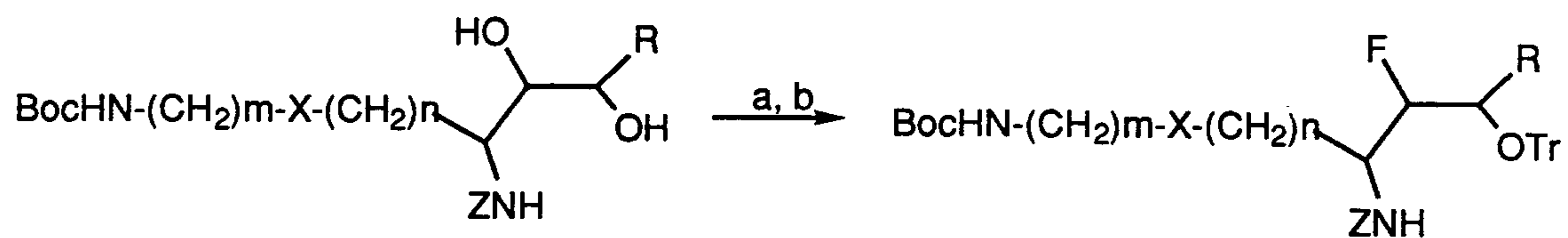
(a) LiAlH_4 , THF, 0 °C - 20 °C; (b) RCH=PPh_3 , THF; (c) OsO_4 , NMMO, acetone- H_2O ; (d) $\text{Cl}_2\text{C=O}$, pyridine.

Scheme 23



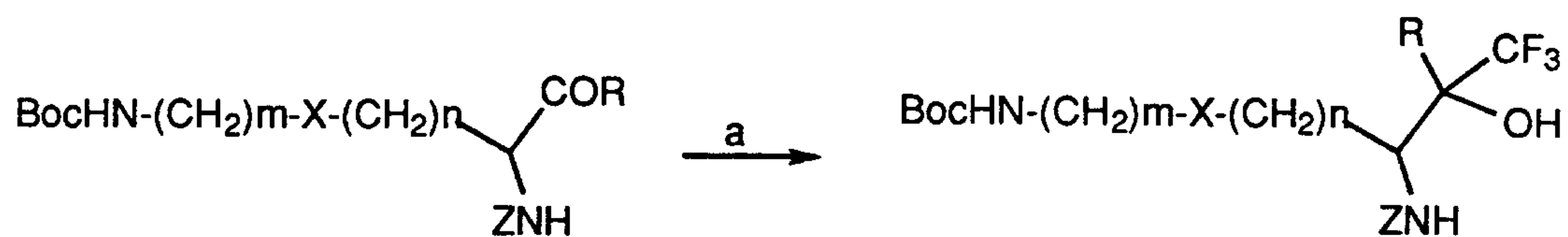
(a) mcpba, DCM, 20 °C; (b) NaSR'' or NaOR'' , toluene-THF, Lewis acid.

Scheme 24



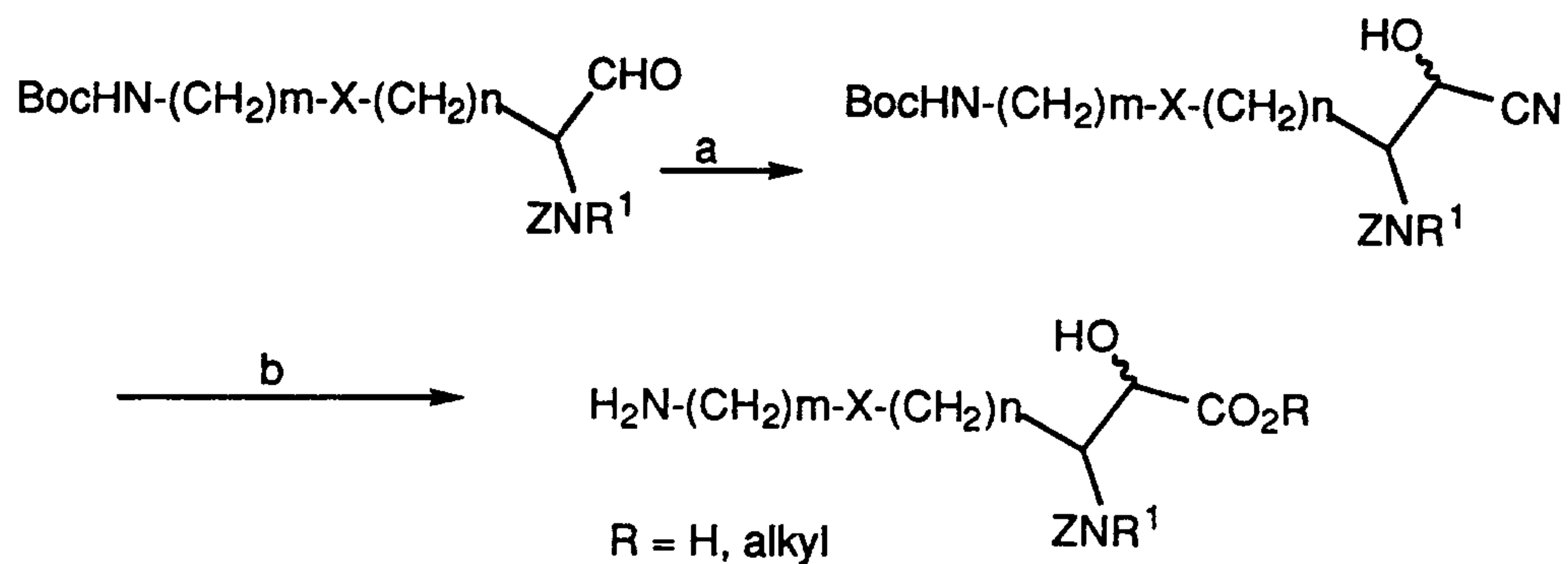
(a) TrCl, pyridine 20 °C; (b) Et₂NSF₃, dioxane.

Scheme 25



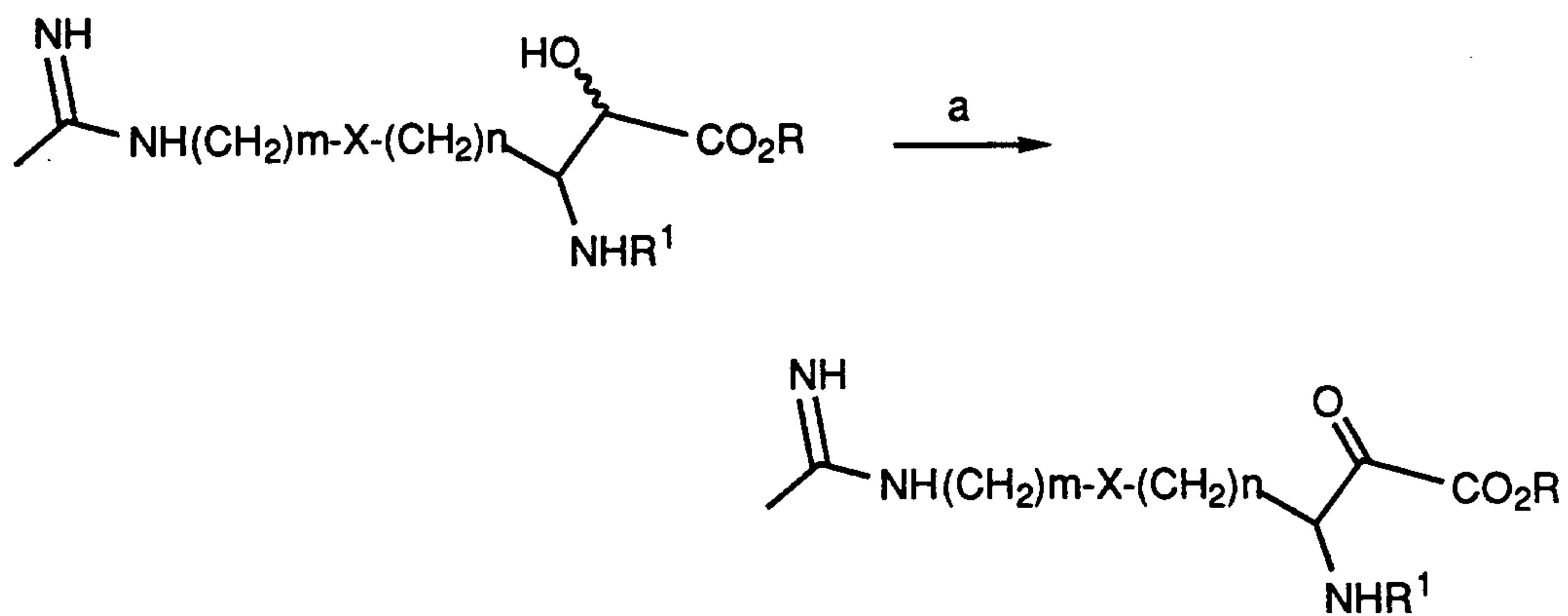
(a) CF₃I, Zn, DMF, -20 °C.

Scheme 26

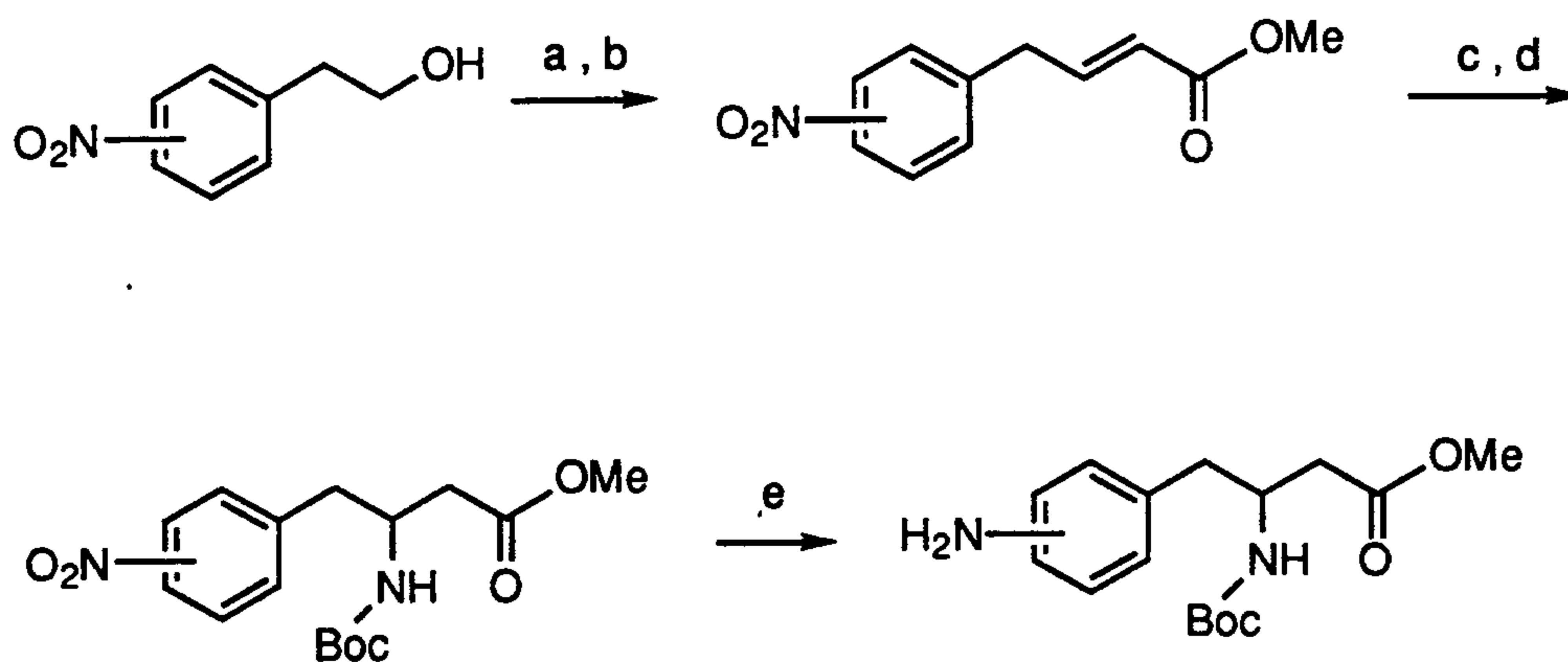


(a) KCN, NaHSO₄; (b) ROH, HCl or H₂O, H⁺.

Scheme 27

(a) MnO₂, H₂O.

Scheme 28



(a) (COCl)₂, TEA, DMSO, DCM; (b) (carbomethoxymethyl)triphenylphosphonium bromide; (c) ammonium chloride; (d) di-*t*-butyl dicarbonate; (e) H₂, Pd/C.

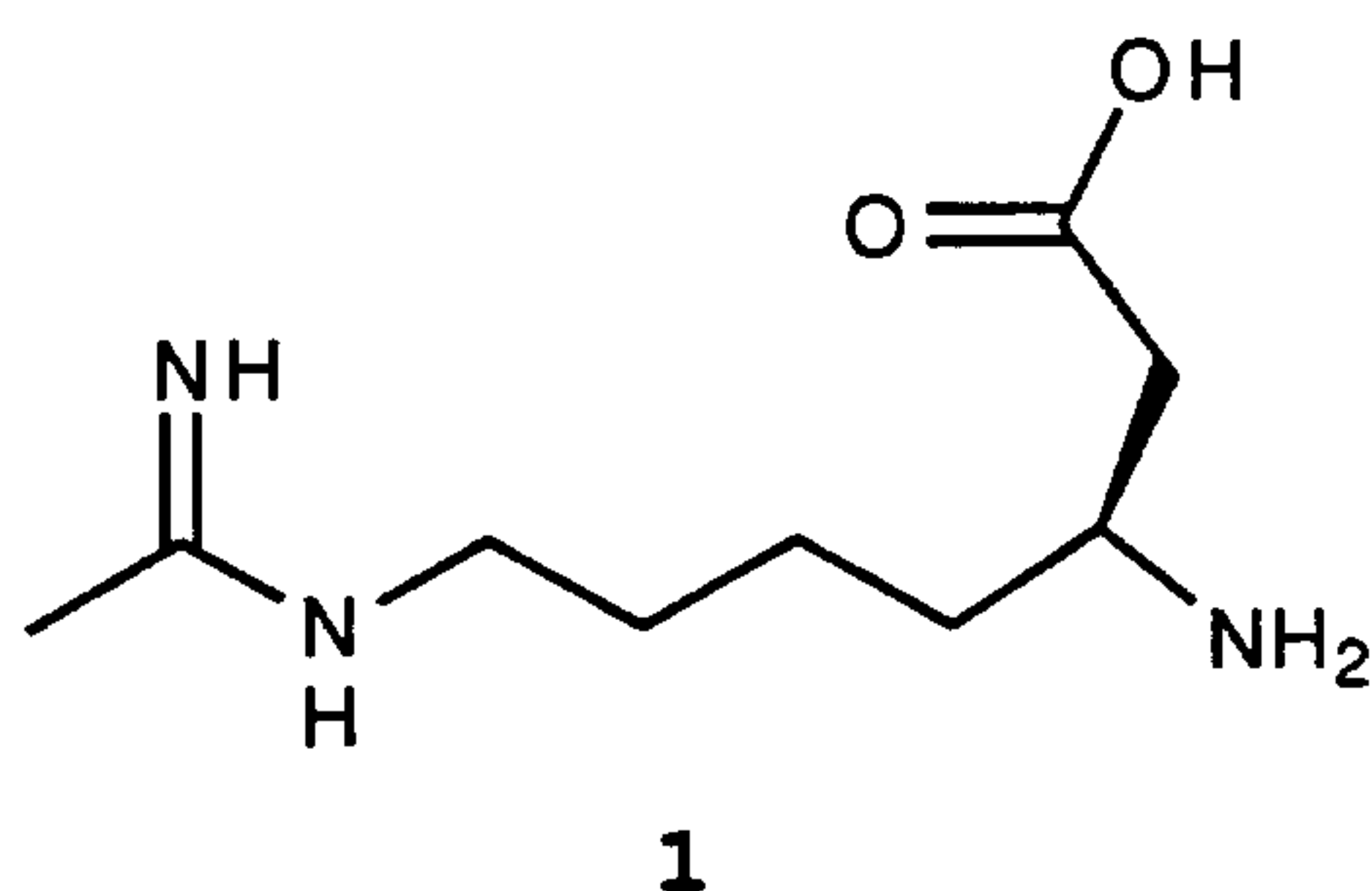
Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. Therefore the following preferred specific embodiments are to be construed
5 as merely illustrative and not limitative of the remainder of the disclosure in any way whatsoever.

All experiments were performed under either dry nitrogen or argon. All solvents and reagents were used without further
10 purification unless otherwise noted. The routine work-up of the reactions involved the addition of the reaction mixture to a mixture of either neutral, or acidic, or basic aqueous solutions and organic solvent. The aqueous layer was extracted n times (x) with the indicated organic solvent.
15 The combined organic extracts were washed n times (x) with the indicated aqueous solutions, dried over anhydrous Na₂SO₄, filtered, concentrated in vacuo, and purified as indicated. Separations by column chromatography were achieved with conditions described by Still et al. (Still, W.C.;
20 Kahn, M.; Mitra, A. Rapid Chromatographic Technique for Preparative Separation with Moderate Resolution. *J. Org. Chem.*, **1978**, 43, 2923-2925.) The hydrochloride salts were made from 1N HCl, HCl in ethanol (EtOH), 2 N in MeOH, or 6 N HCl in dioxane. Thin layer chromatograms were run on 0.25
25 mm EM precoated plates of silica gel 60 F254. High performance liquid chromatograms (HPLC) were obtained from C-8 or C-18 reverse phase columns which were obtained from several vendors. Analytical samples were dried in an Abderhalden apparatus at either 56°C or 78°C. ¹H NMR
30 spectra were obtained from either General Electric QE-300 or Varian VXR 400 MHz spectrometer with tetramethylsilane as an internal standard. ¹³C NMR were obtained from a Varian spectrometer at 125.8 MHz with tetramethylsilane as an internal standard.

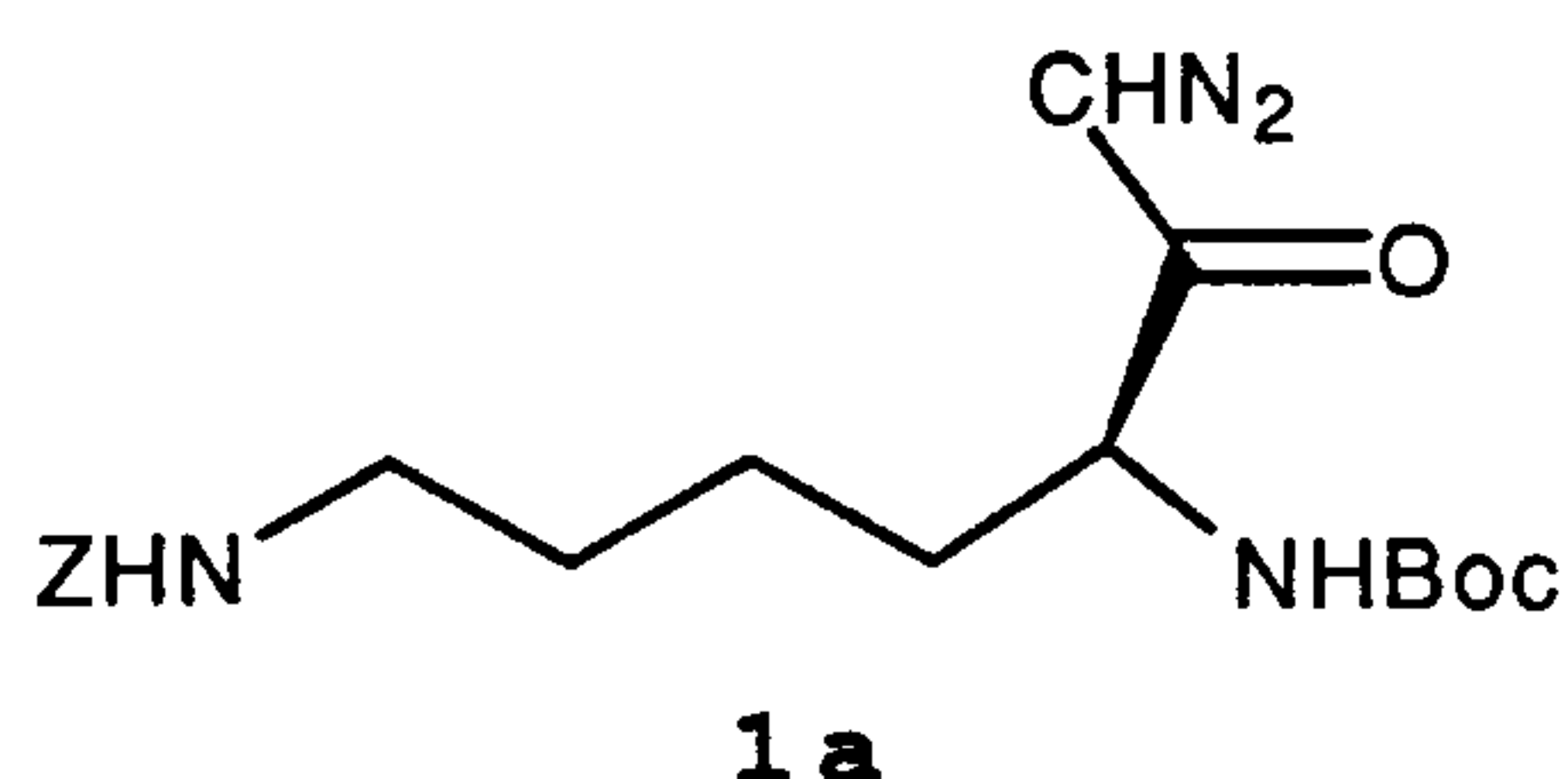
35

Example 1

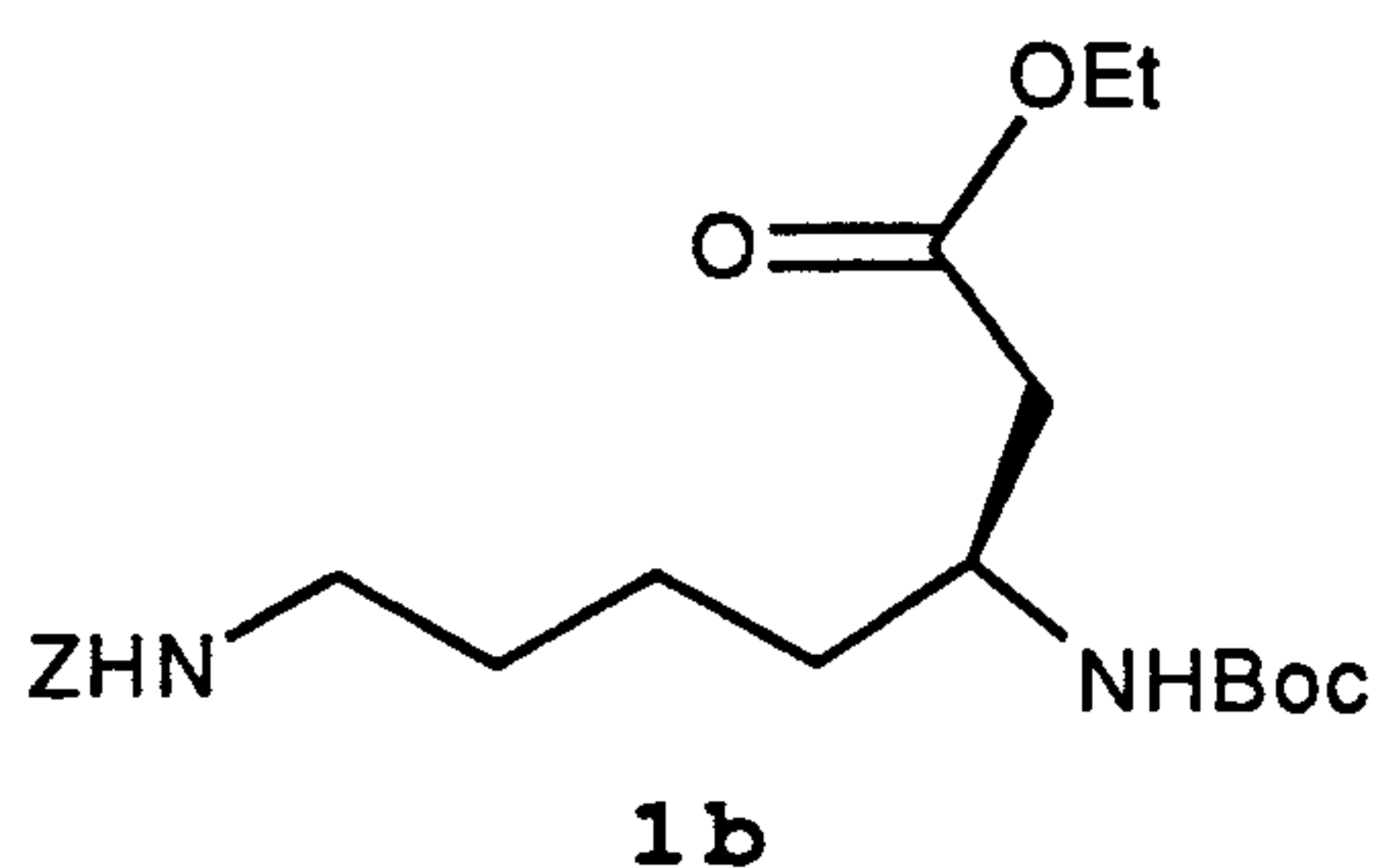
32

3S-amino-7-[(1-iminoethyl)amino]heptanoic acid

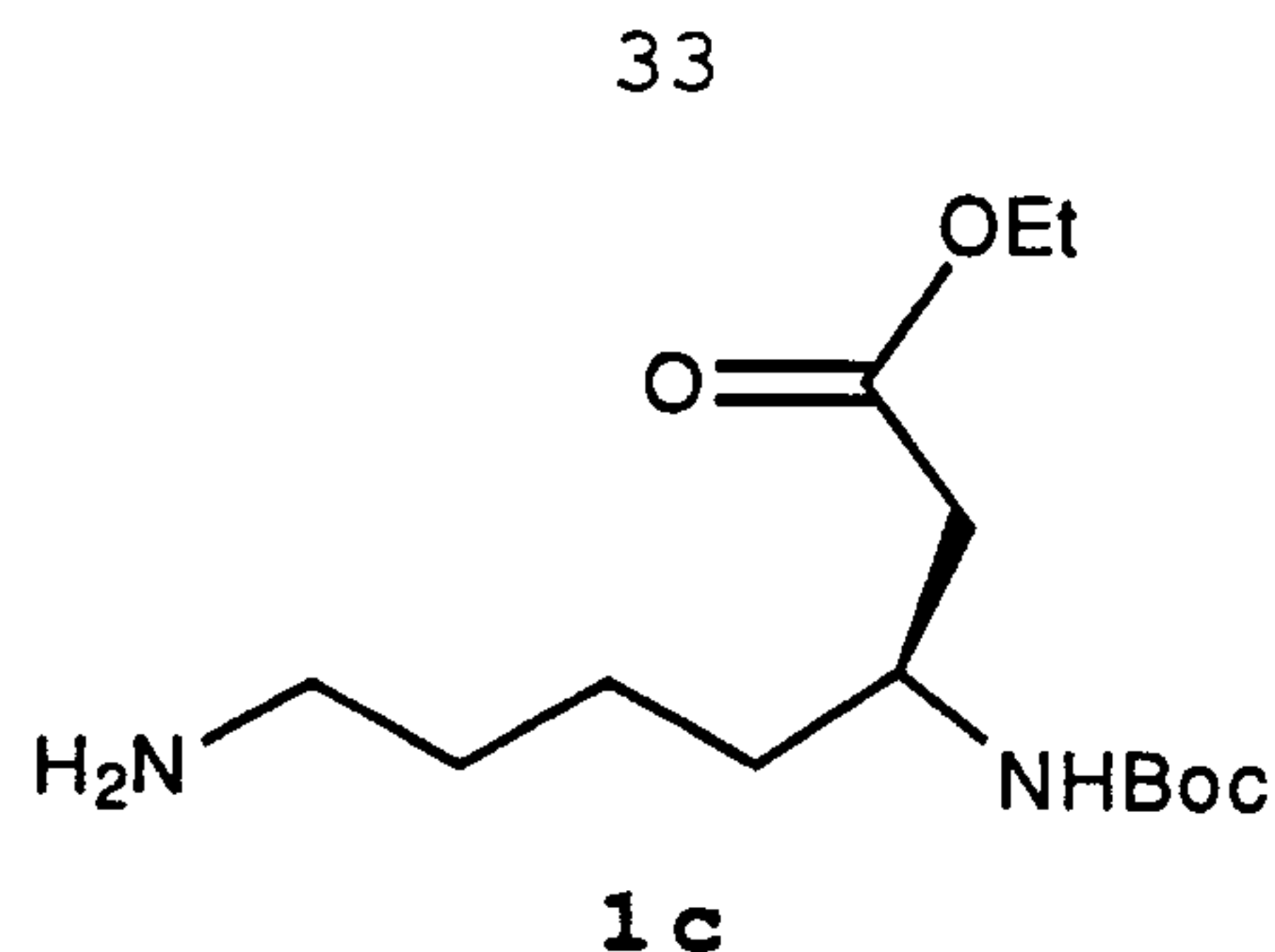
5



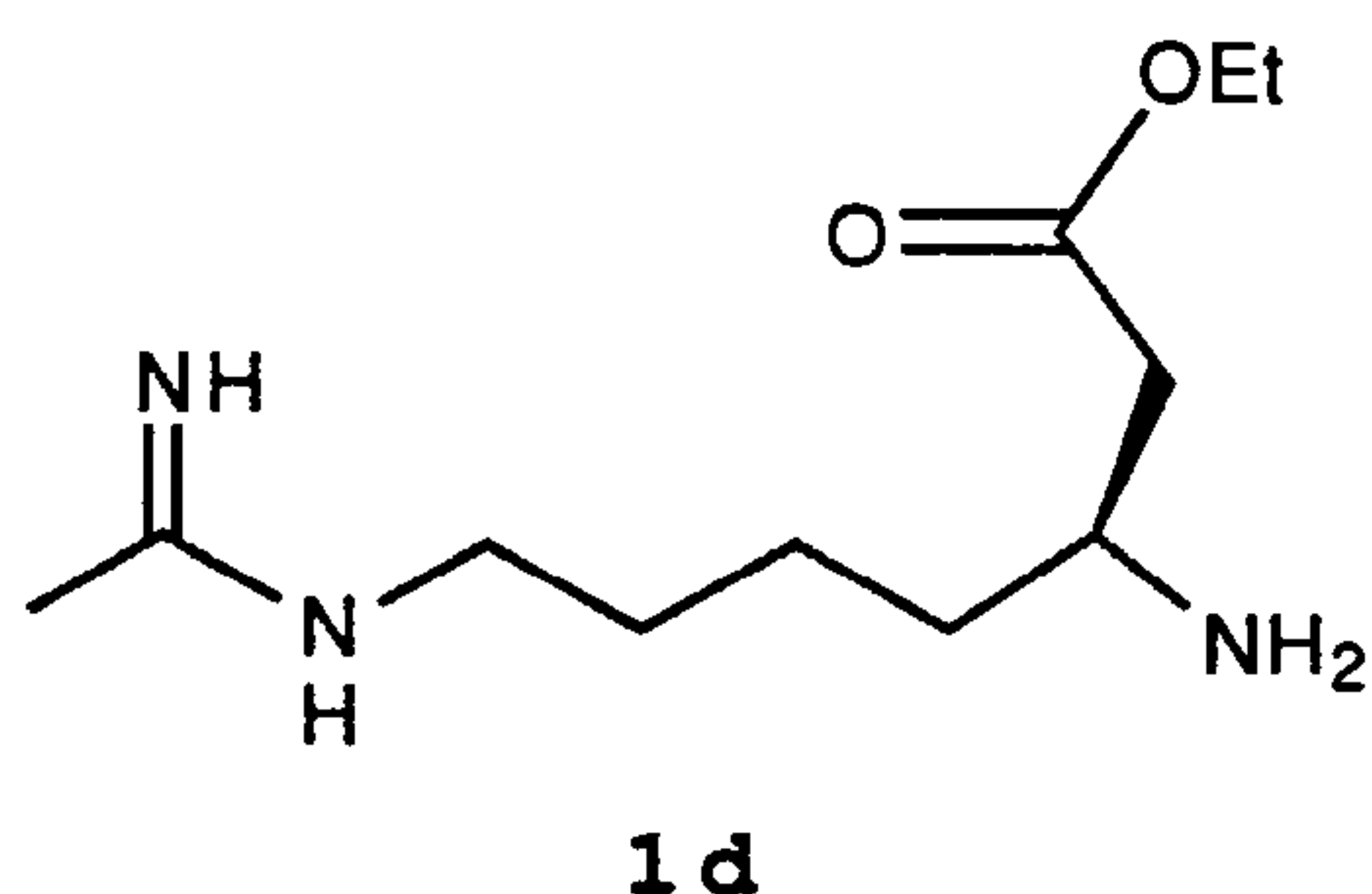
- 10 **1a.** Boc-L-Lys(Z)-OH in 50 mL THF (3.8 g, 10 mmol) was
 reacted with isobutyl chloroformate (1.4 mL, (10 mmol) in
 the presence of NMM (1.1 mL, 10 mmol). The salt was filtered
 and the mixed anhydride was reacted with 25 mmol
 15 to give an oil. This structure and subsequent structures
 were characterized by ¹H NMR.



- 20 **1b.** **1a** dissolved in 50 mL EtOH was treated with Ag
 benzoate (0.5 g) in the presence of TEA (5 mL) for 2 h.
 After filtration, the β-amino acid ester was purified by
 column chromatography to give 0.84 g of product.



1c. **1b** (0.84 g 12 mmol) dissolved in 30 mL MeOH was reduced in the presence of 1 g ammonium formate and 0.2 g Pd black for 60 min. After filtration and evaporation, product was recovered.



Ethyl 3S-amino-7-[(1-iminoethyl)amino]heptanoate

1d. **1c** in 10 mL DMF was treated with methyl acetimidate (0.692 g, 6 mmol) and N,N-diisopropylethylamine (1.05 mL, 6 mmol) overnight. Solvent was removed *in vacuo* and the residue treated with TFA (10 mL) for 30 min. The reaction was diluted with H₂O and purified by HPLC to yield 0.16 g (35.1%) of an oil. FAB MS: MH⁺=230.2

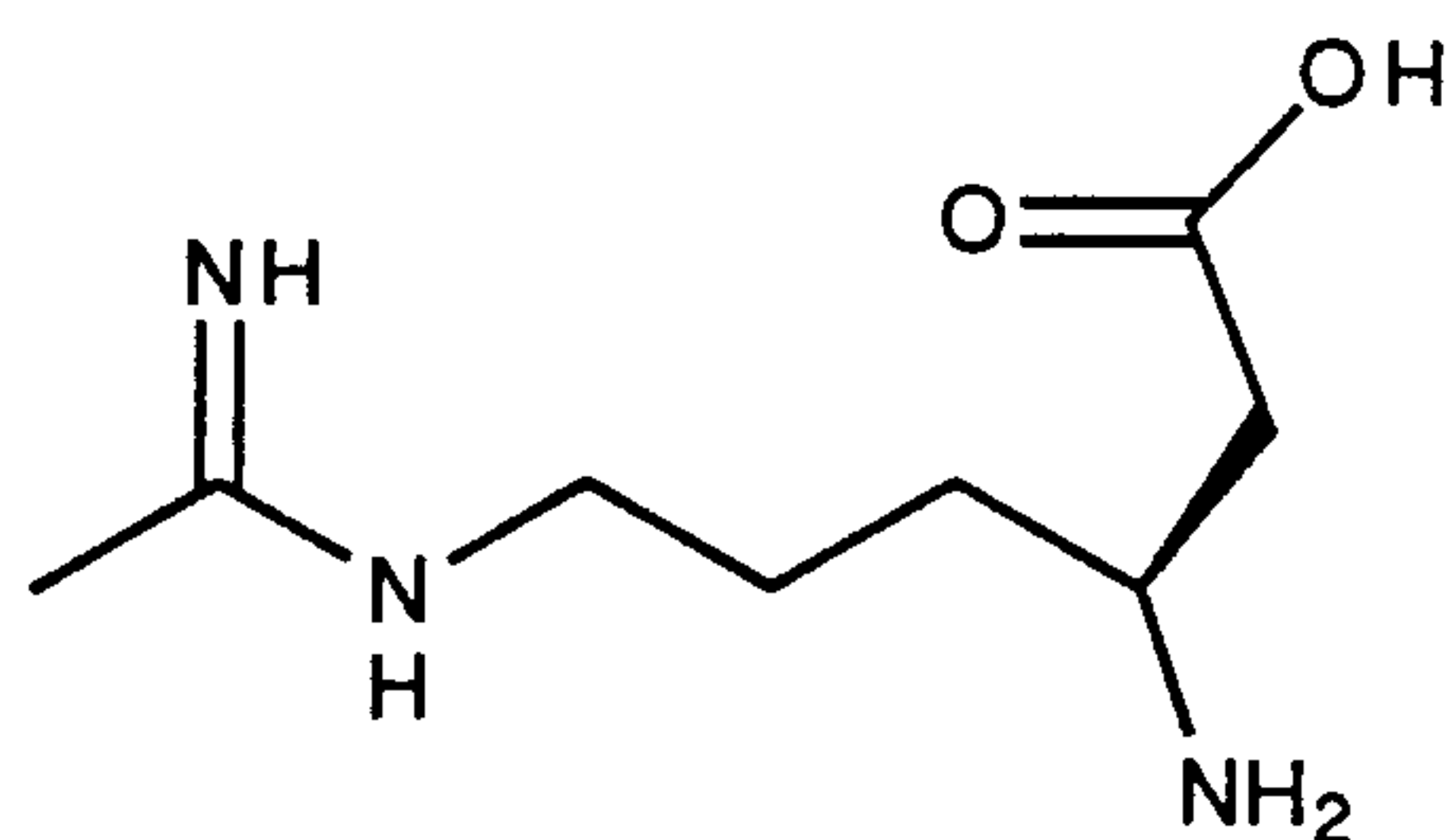
20

1

1. **1d** (0.12 g, 0.52 mmol) dissolved in 20 mL 2N HCl was refluxed for 60 min. The reaction was diluted with H₂O and lyophilized to yield 0.107 g (100%) of an oil. FAB MS: MH⁺=202.3

Example 2

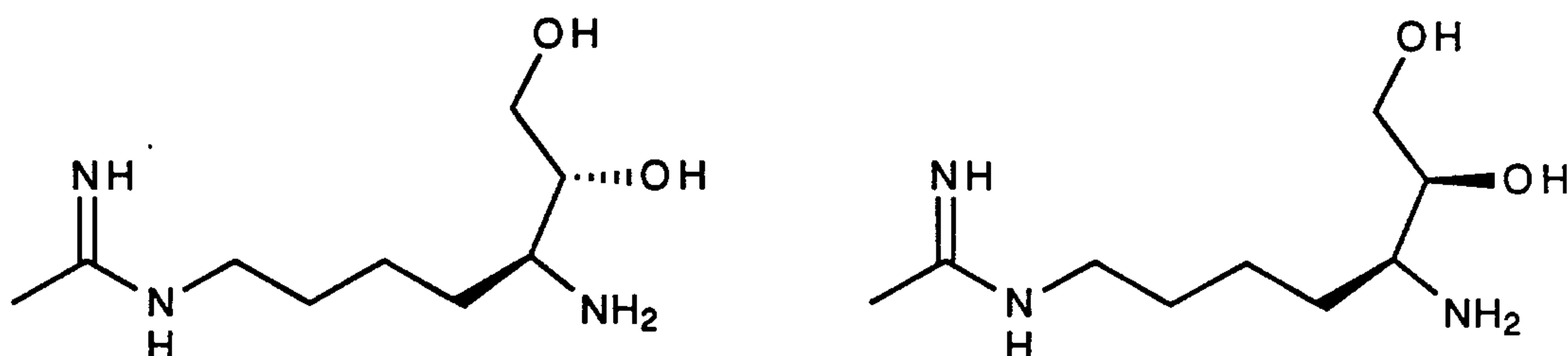
34

3S-amino-6-[(1-iminoethyl)amino]hexanoic acid**2**

5

2. Example 2 was prepared in the same manner as described for example 1 starting with Boc-Orn(Z)-OH (3.6 g, 10 mmol) to yield 0.123 g (33%) of an oil. FAB MS: $MH^+ = 188.0$

10

Example 3**N-(5S-amino-6,7-dihydroxyheptyl)ethanimidamide, dihydrochloride**

The absolute stereochemistry of the hydroxyl group at position C-6 has not been determined. The diastereomers have been separated as described below. A difference in the biological activity between the diastereomers is seen.

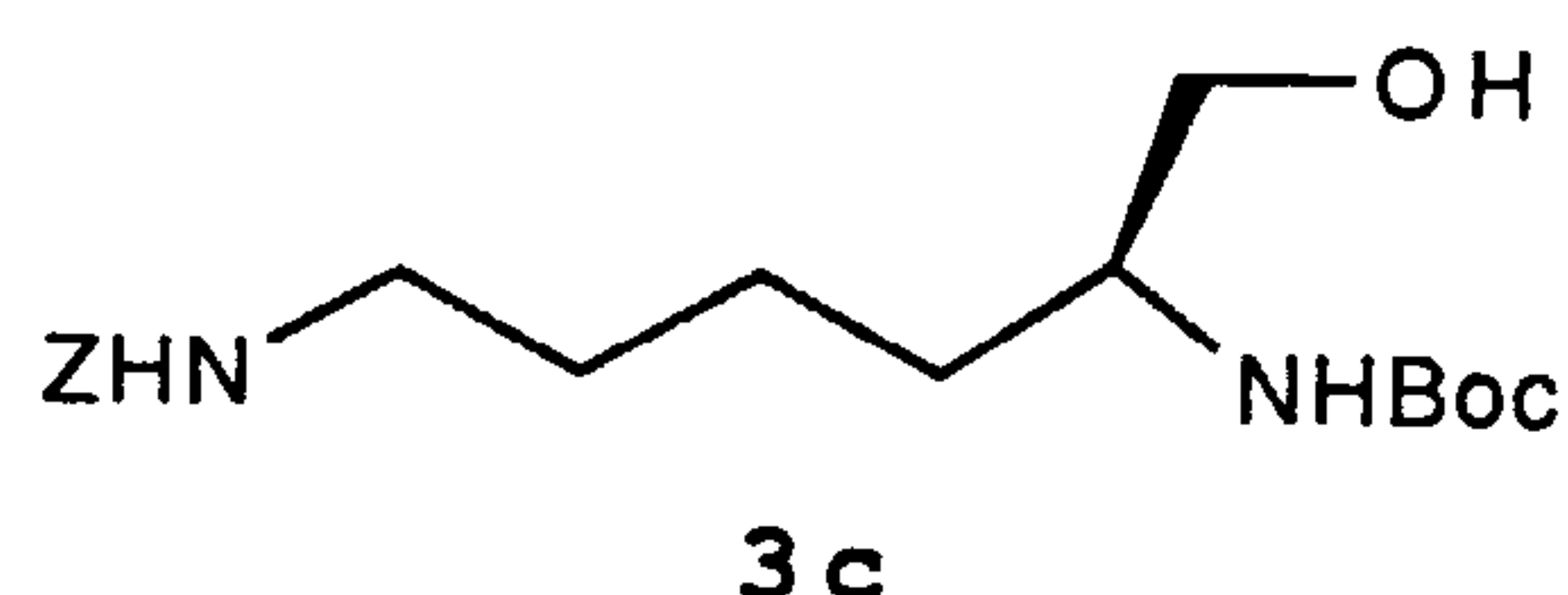
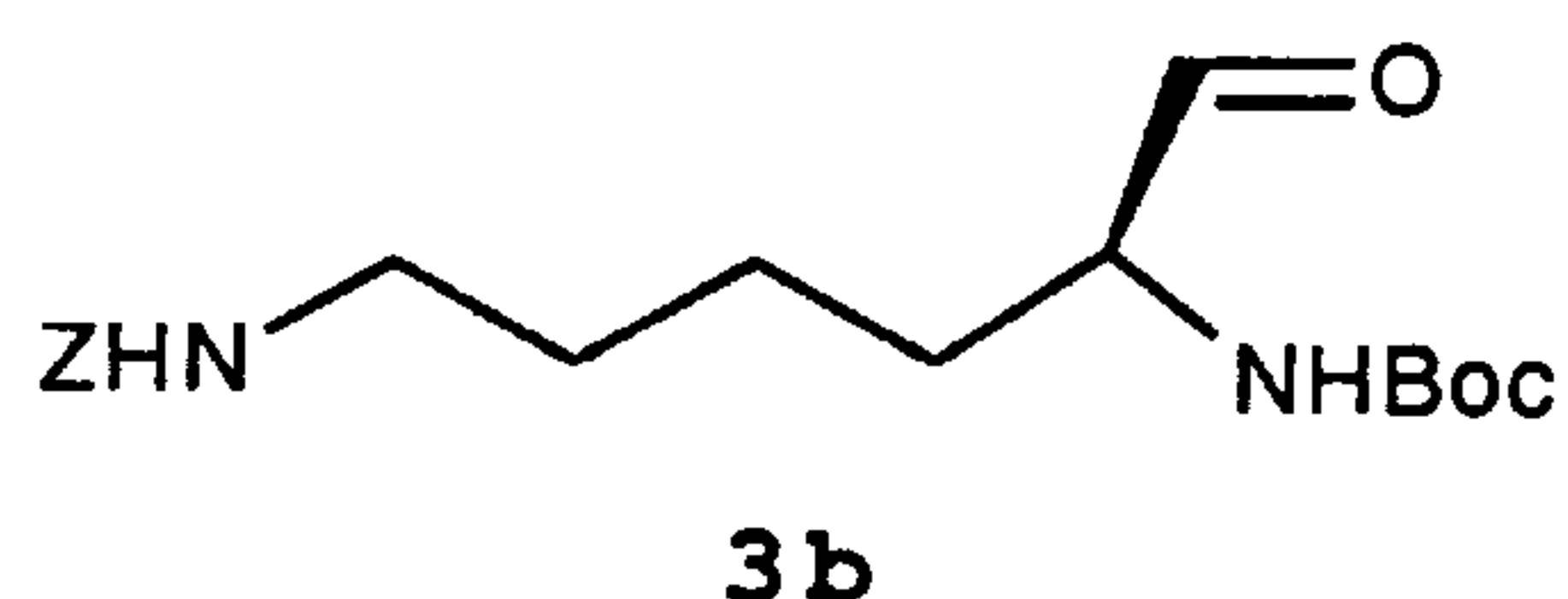
15

3

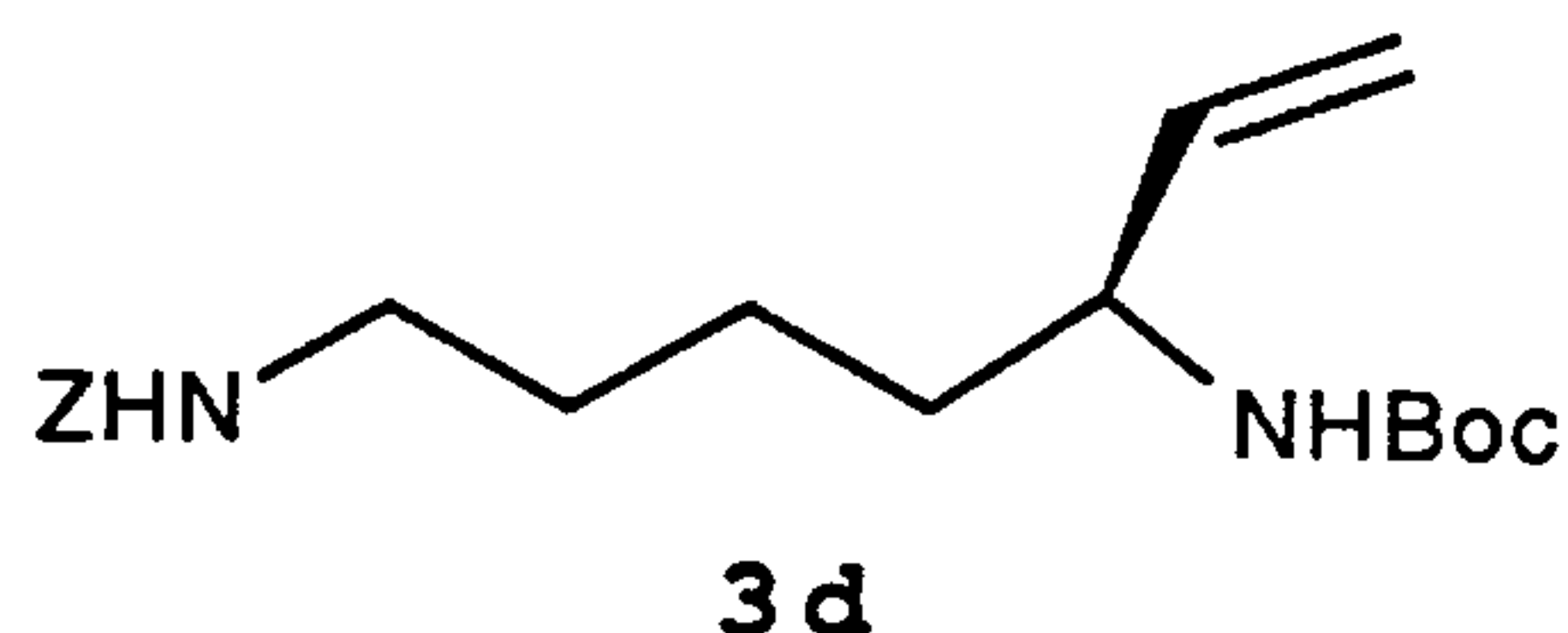
N- α -Boc-N- ϵ -Z-L-Lys-OMe (**3a**)

20

3a. To a stirring solution of cesium carbonate (32.6 g, 0.10 mol) in 150 mL DMF was added N- α -Boc-N- ϵ -Z-Lys (68.3 g, 0.18 mol). After 10 min, iodomethane (51.1g, 0.36 mol) was added. After 18 h, solvent was removed *in vacuo*. The resultant gum was washed with hexane and the hexane was decanted. The product was dissolved in 100 mL of DCM and filtered through a 100 x 70 mm pad of EM silica gel. The silica was washed with 900 mL DCM and 300 mL EtOAc which were combined. The solvent was removed *in vacuo* to yield 66.4 g (94 %) of product.

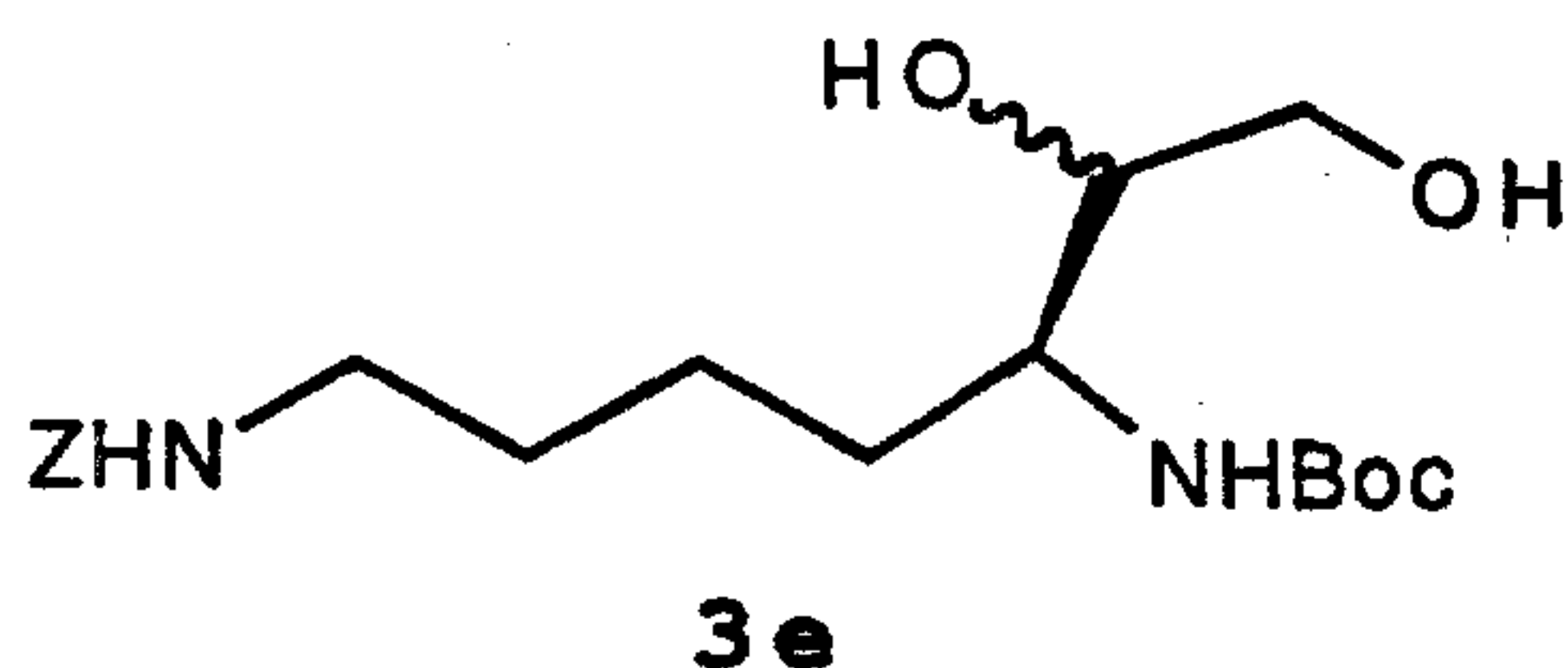


3b, c. To a stirring solution of **3a** (7.9 g, 20 mmol) in 100 mL dry toluene cooled to -70°C was added dropwise over 10 min 1M DIBAL-H in toluene (40 mL, 40 mmol). After stirring an additional 20 min, the reaction was quenched with 4 mL MeOH. Upon removal of the ice bath, 150 mL of saturated solution of Rochelle salt was added to the reaction. After stirring for 1 h, the layers were separated. The aqueous layer was extracted with 2x 150 mL EtOAc. The combined organic layers were washed with 2x 200 mL H₂O, dried, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography according to Still et al. to yield 5.37g (74 %) of **3b** and 0.70 g (10 %) of **3c**. Both **3b** and **3c** were white solids.



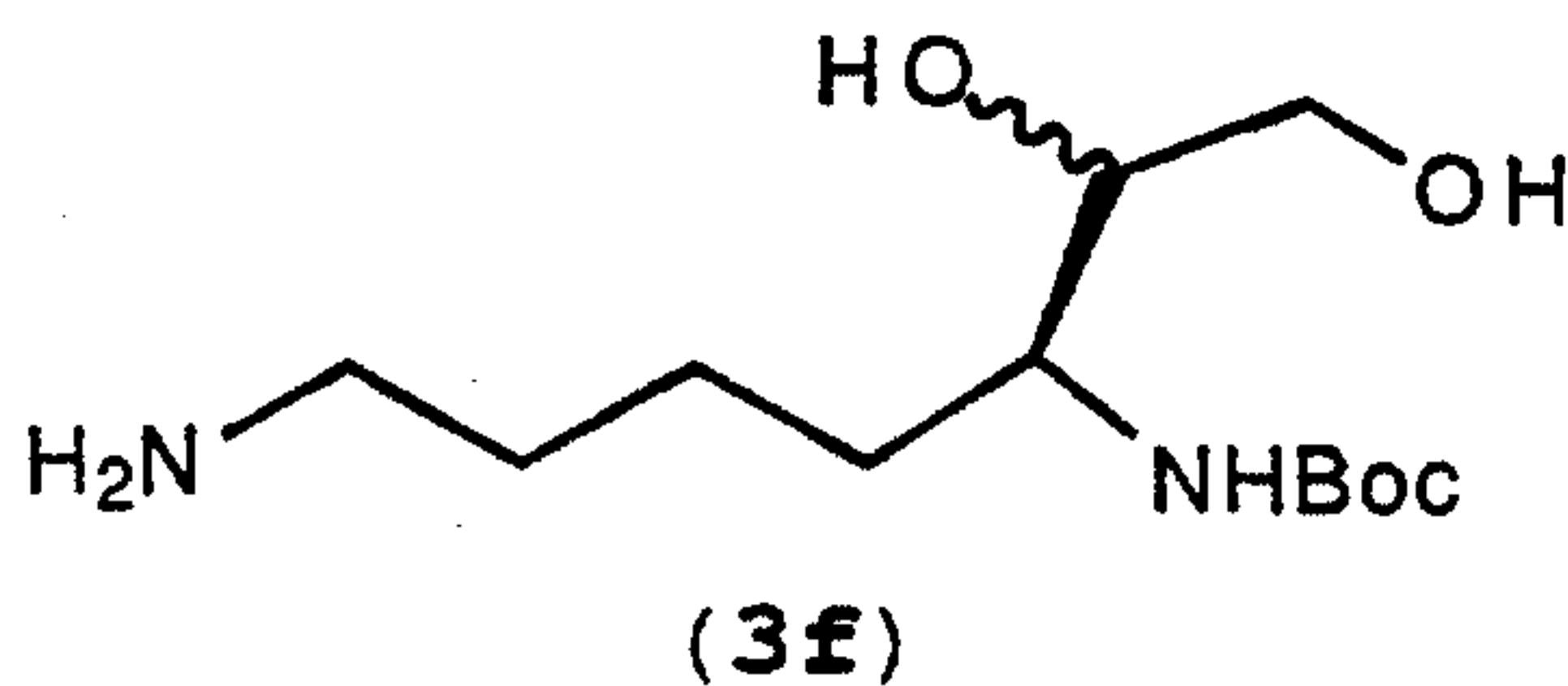
36

3d. To a stirring suspension of methyltriphenylphosphonium bromide (2.18 g, 6.1 mmol) in 50 mL of Et₂O was added dropwise 0.5 M potassium hexamethyldisilazide in toluene (12.2 mL, 6.1 mmol). After stirring for 1.5 h, **3b** (2.22 g, 6.1 mmol) in 50 mL of Et₂O was added. After 16 h, a white solid was filtered from the reaction. The filtrate was concentrated in vacuo. The residue was purified by flash chromatography to yield 1.11 g (50%) of **3d**, a clear colorless gum. Anal calcd for C₂₀H₃₀N₂O₄·0.2 H₂O: C, 65.62; H, 8.37; N, 7.65. Found: C, 65.65; H, 8.07; N, 7.59.



15

3e. To a stirring solution of **3d** (1.20 g, 3.3 mmol) in 80 mL of acetone:H₂O (3:1) was added 4-methylmorpholine N-oxide (0.64 g, 4.8 mmol) and 2.5 % OsO₄ in t-BuOH (3.4 mL, 3.4 mmol). After 18 h, 120 mL of H₂O, 8 g of celite™, and 1.6 g Na₂S₂O₄ were added to the reaction. The reaction was filtered through a pad of wet celite™. To the filtrate was added 200 mL of 1M KHSO₄. The filtrate was extracted with 3x 200 mL EtOAc. The combined organic layers were dried, filtered, and stripped. The residue was purified by flash chromatography to yield 0.93 g (71 %) of **3e**. Anal calcd for C₂₀H₃₂N₂O₆·0.25 H₂O: C, 59.91; H, 8.17; N, 6.99. Found: C, 59.75; H, 8.42; N, 6.77.



30

37

3f. Benzyloxycarbonyl protecting group was removed from **3e** (1.38 g, 3.5 mmol) by catalytic hydrogenation using Pd black as the catalyst yielding **3f** quantitatively.

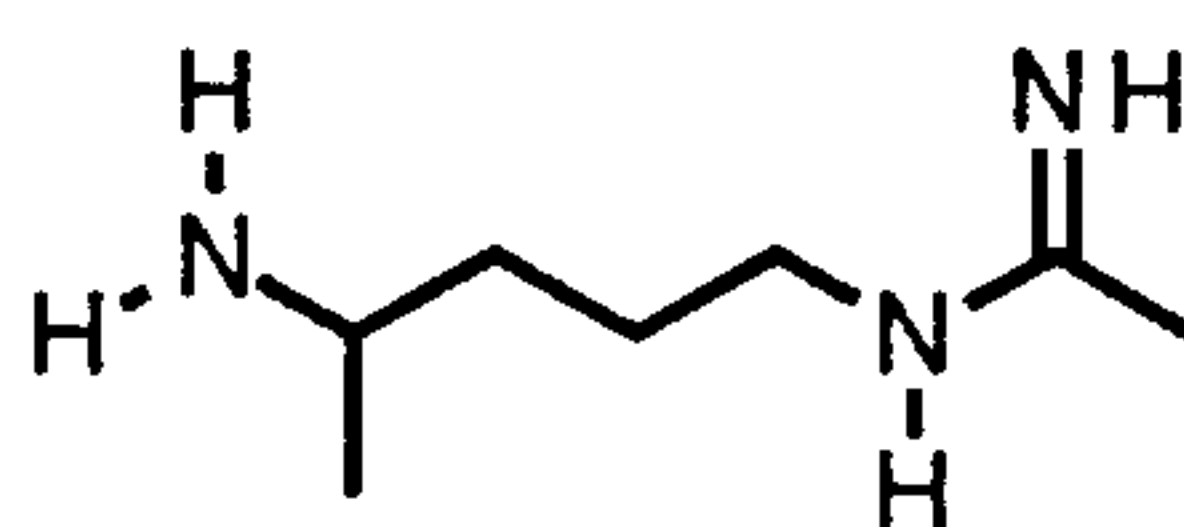
5

3

3A, 3B. To a stirring solution of **3f** (3.90 g, 14.9 mmol) and TEA (3.3 mL, 24 mmol) in 10 mL of DMF was added methyl acetimidate (2.44 g, 22.2 mmol). After 16 h, TEA·HCl was filtered from the reaction and washed with a minimum of DMF. The filtrate was adjusted to pH 3 with 1N HCl. The filtrate was concentrated under high vacuum. The residue was applied to a reverse phase column (YMC AQ-363-10P, ODS) using a gradient of 20 % CH₃CN/0.025 % HOAc to 50 % CH₃CN/0.025 % HOAc. The two diastereomers were separated. The first eluting isomer was treated with 1N HCl for 1 h at ambient temperature. The aqueous solution was lyophilized. The yield was 0.51 g of **3A**. The second eluting isomer was treated in the same fashion to yield 0.40 g of **3B**. Anal calcd for (**3B**) C₉H₂₁N₃O₂·1.75HCl·0.75 H₂O: C, 38.52; H, 8.71; N, 14.97. Found: C, 38.60; H, 8.73; N, 13.34 .

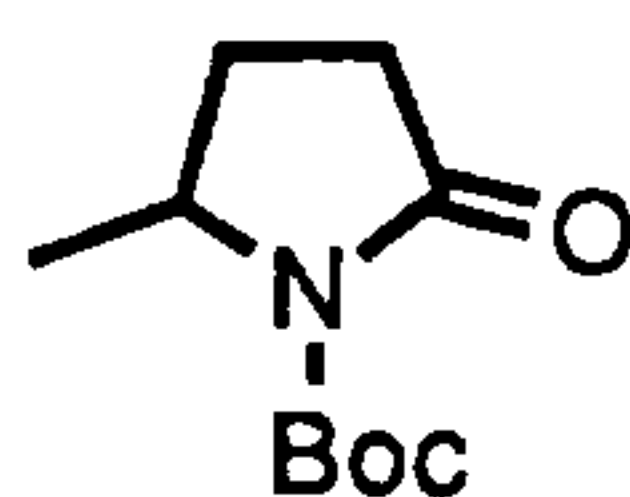
25

Example 4
N1-(1-iminoethyl)-1,4-pentanediamine,
dihydrochloride

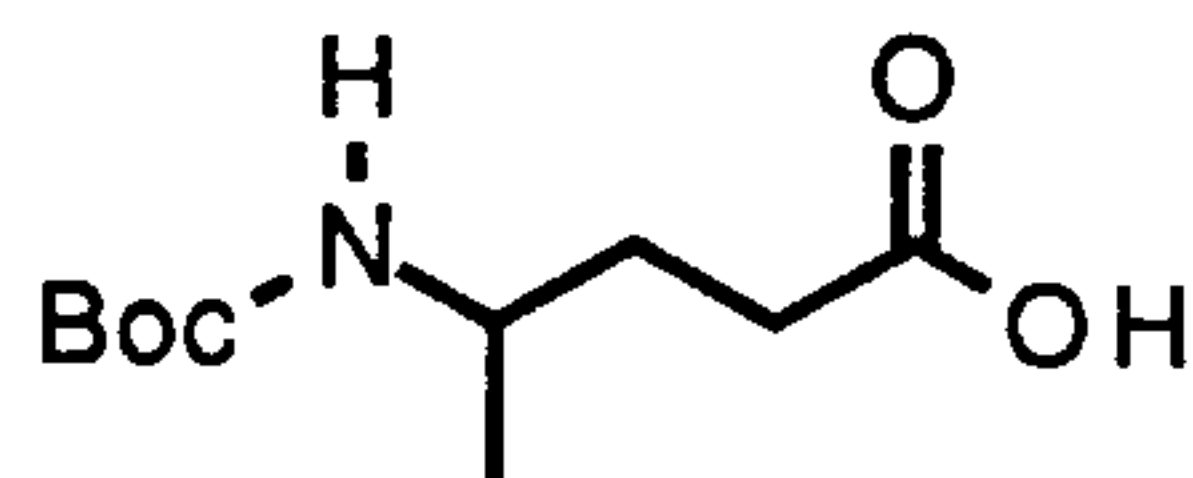


30

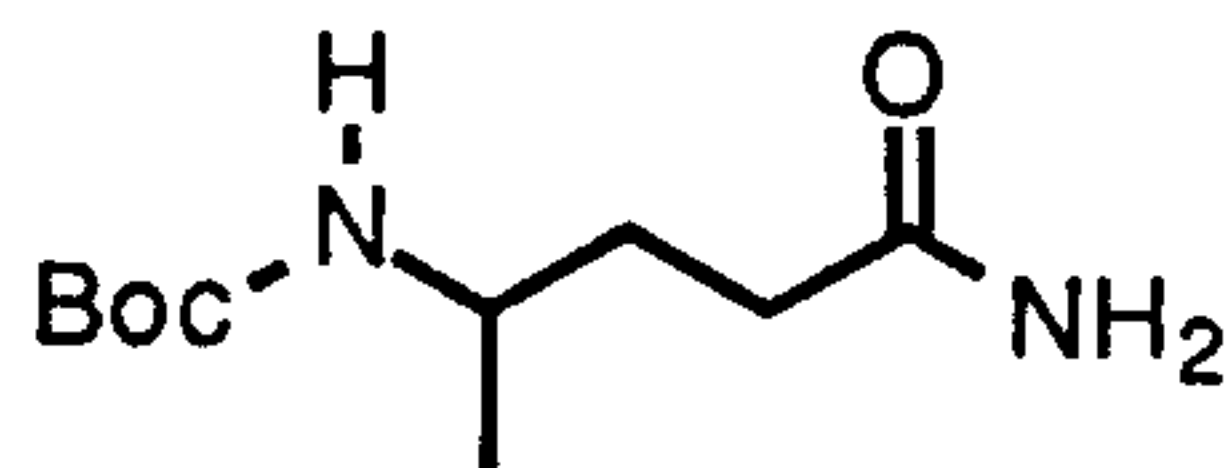
38

**4 a**

4a. A solution of 5-methyl-2-pyrrolidinone (50 g, 0.5 mol), di-t-butyl dicarbonate (165 g, 0.76 mol), DMAP (62 g, 0.5 mol) and Et₃N (250 mL) in CH₂Cl₂ (250 mL) was stirred at room temperature for 24 h. The solvent was concentrated *in vacuo* and the resulting oily red solid suspended in Et₂O and filtered. The Et₂O solution was passed through a pad of silica gel. The solvent was removed to yield an orange liquid. The product was chromatographed to yield 82 g (83%) of a yellow liquid.

**4 b**

4b. Sodium hydroxide (2.24 g, 56 mmol) was added to a stirring solution of **4a** (4.0 g, 20 mmol) in THF:H₂O (175 mL:75 mL). The resulting solution was stirred for 2 h. The solvent was concentrated *in vacuo* to 75 mL. The solution was acidified with citric acid (1 M, 75 mL), extracted with EtOAc (200 mL), dried, and concentrated *in vacuo* to yield 5.36 g of an oil. The product was crystallized from Et₂O/hexane to yield 4.24 g (98%) of a white solid.

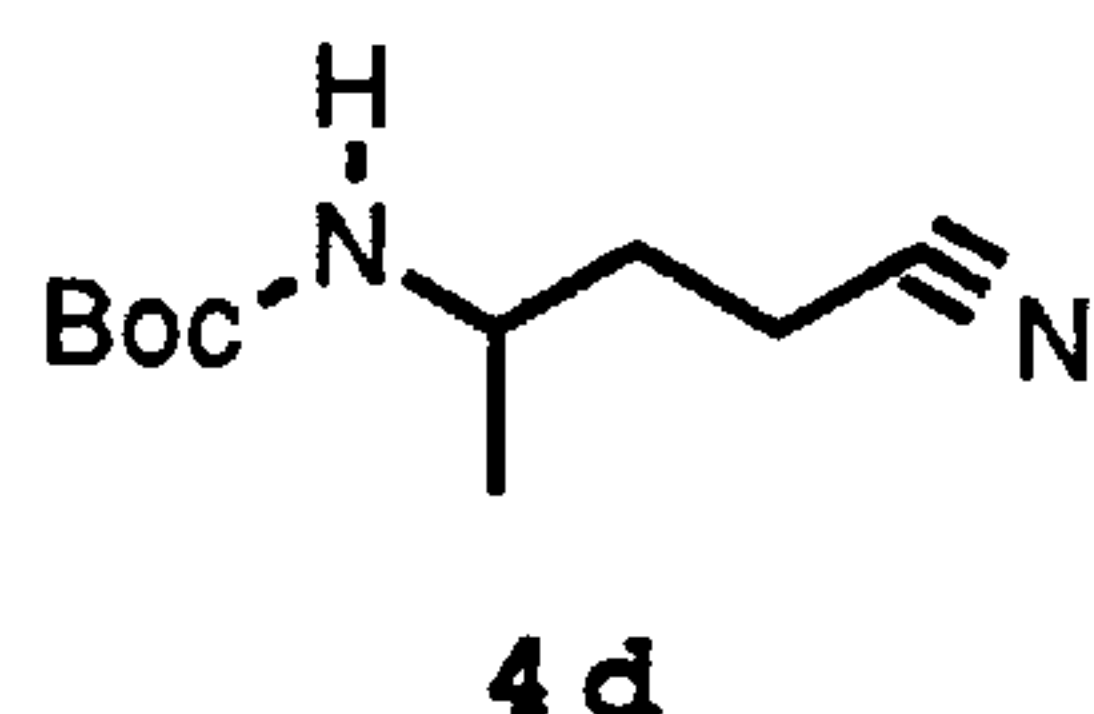
**4 c**

4c. To a stirred solution of **4b** (4.0 g, 18 mmol) and TEA (2.6 mL, 18 mmol) in THF (50 mL) at -10°C was added isobutyl

39

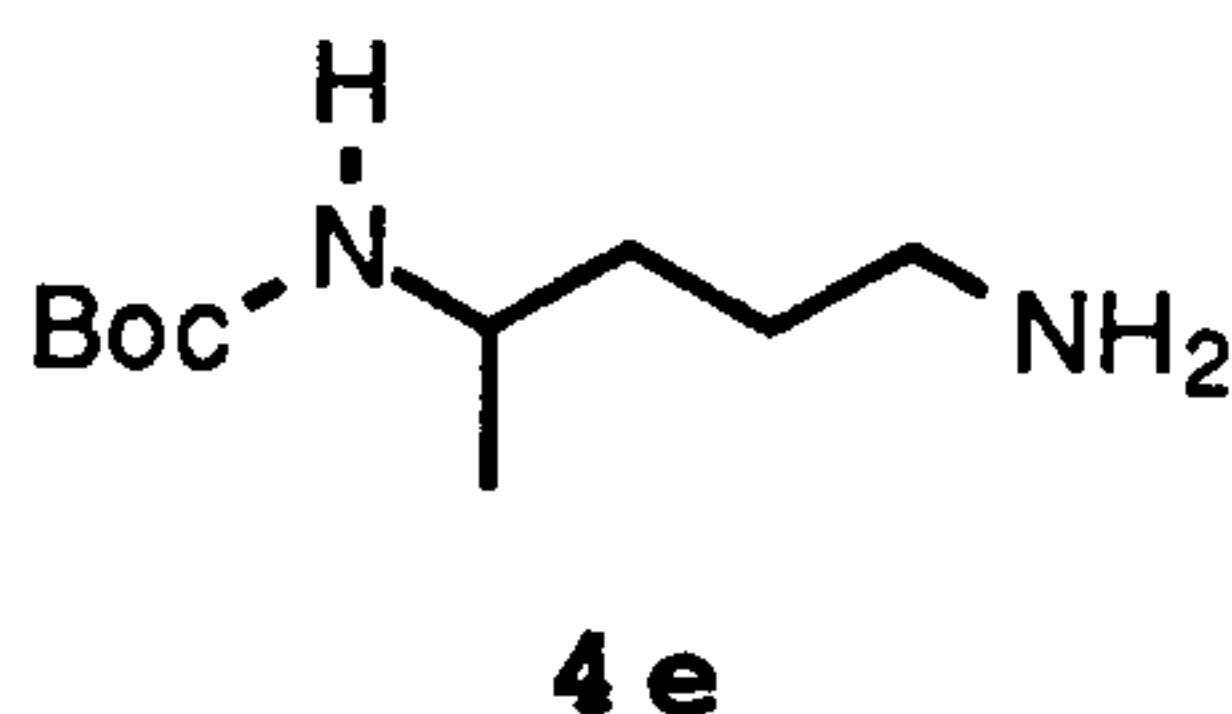
chloroformate (2.39 mL, 18 mmol) dropwise and the solution stirred for 20 min. Ammonium hydroxide (3.9 mL, 28%) was added and the resulting solution was stirred for 18 h allowing to warm to room temperature. The solution was concentrated *in vacuo* and the residue suspended in boiling EtOAc (80 mL) and filtered. This was repeated. The filtrate was concentrated to 30 mL and the solid collected to yield 3.82 g.

10



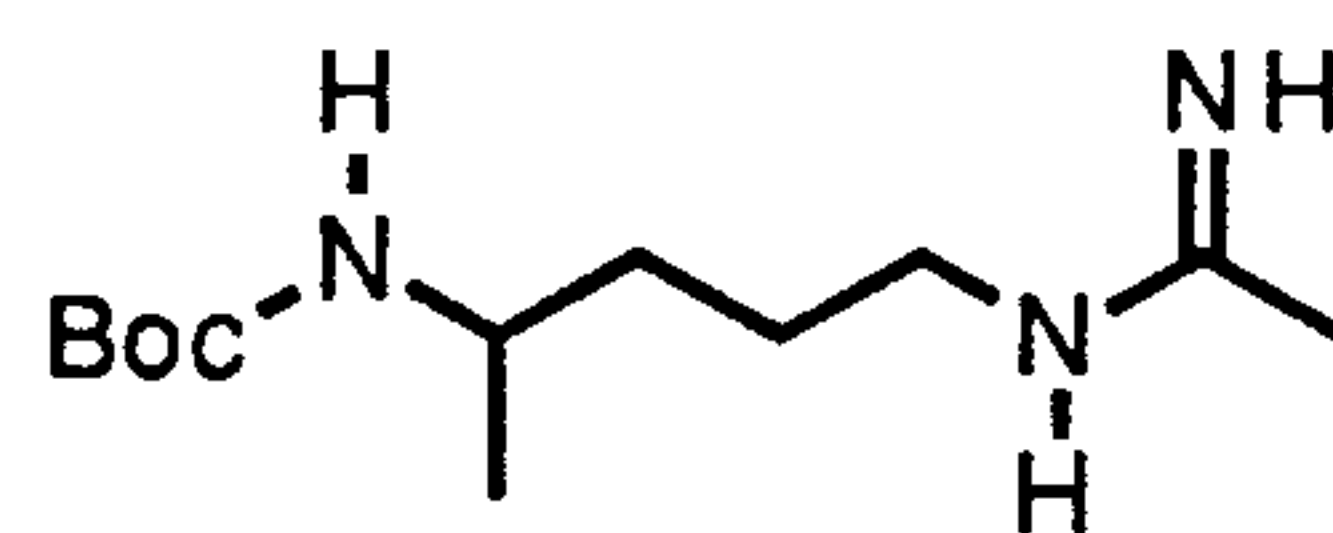
4d. To a stirred solution of **4c** (3.5 g, 16 mmol) in THF (20 mL) at 0°C was added TFAA (2.5 mL, 17.5 mmol) dropwise and the solution stirred for 20 min. The solution was poured onto Et₂O (125 mL) and NaHCO₃ (satd, 25 mL), the layers separated and the organic solution extracted with NaHCO₃ (satd) and brine (satd.), dried, filtered, and concentrated *in vacuo* to yield 2.88 g of an oil. The product was vacuum distilled (bp 130°C @ 0.6 mmHg) to yield 2.2 g (69%) of a yellow liquid.

25

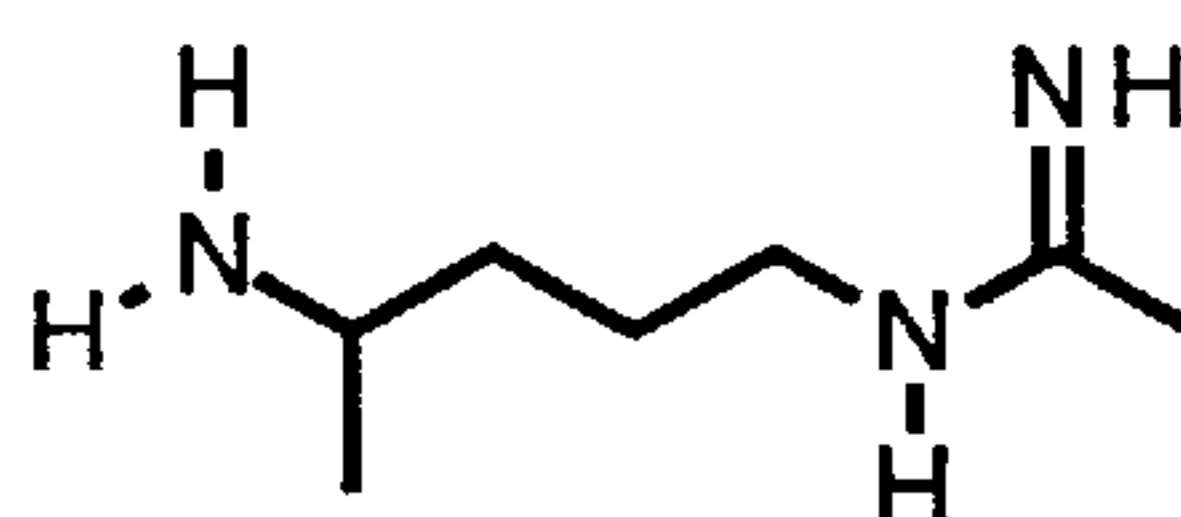


4e. A solution of **4d** (1.7 g, 8.6 mmol) in EtOH was treated with H₂ (300 psi) over Raney nickel at 50°C for 8 h. The reaction mixture was filtered and concentrated *in vacuo* to yield 1.25 g (73%) of a colorless oil.

40

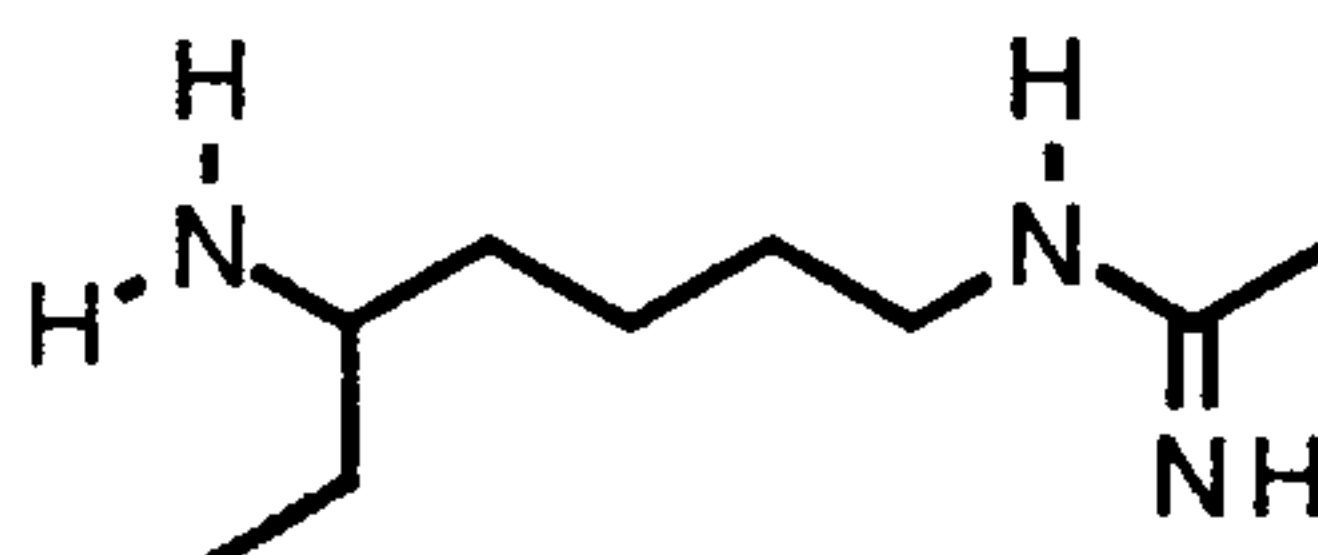
**4f**

5 **4f.** A solution of **4e** (1.0 g, 4.9 mmol) and ethyl acetimidate hydrochloride (0.62 g, 5 mmol) in anhyd. EtOH (25 mL) was stirred for 18 h. The reaction solution was concentrated *in vacuo* to yield 1.46 g of a white foam. This material was used in the next step without further
10 purification.

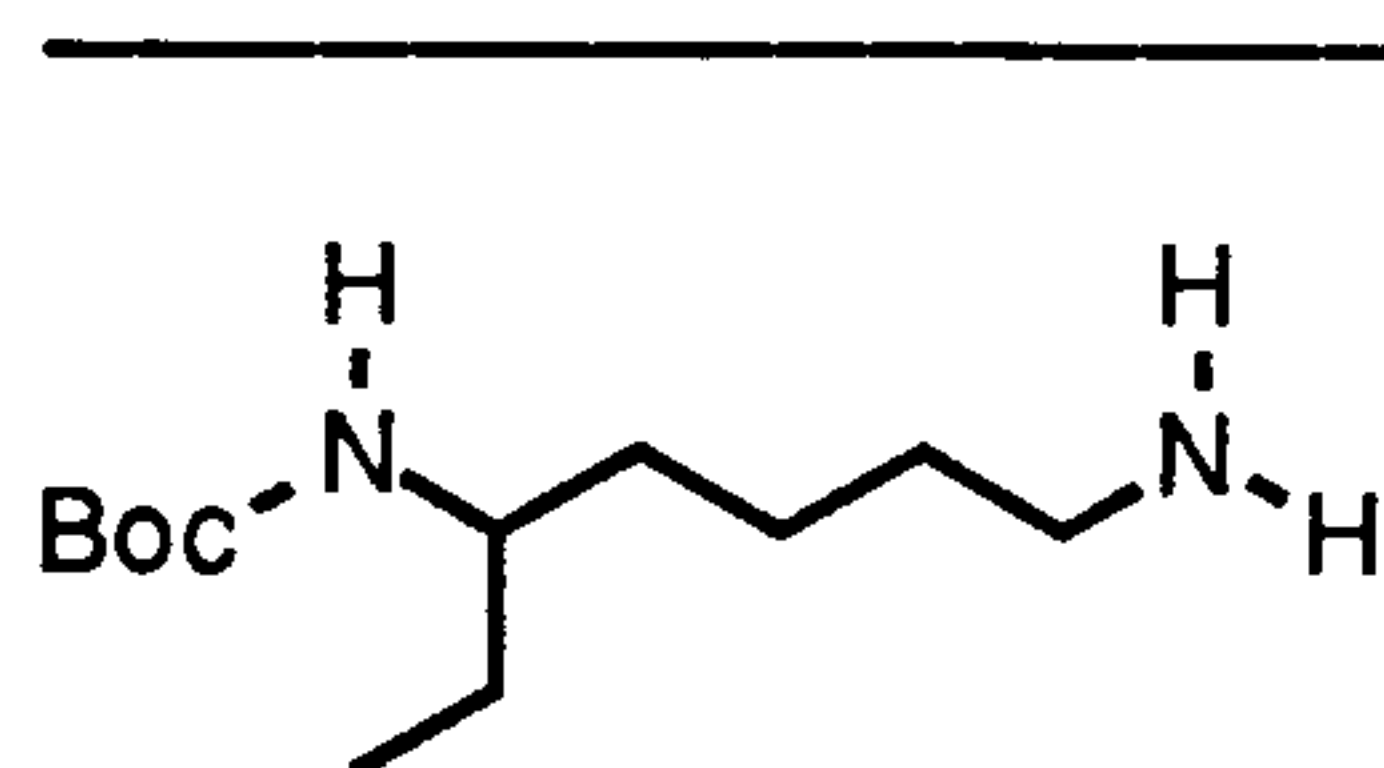
**4**

15 **4.** A solution of **4f** (1.46 g, 4.9 mmol) in acetone (25 mL) was treated with HCl (10 mL, 2 M in MeOH), and stirred for 10 min. The reaction mixture was concentrated *in vacuo* and triturated with ethanol and THF to yield an oil. Crystallization of the oil was attempted from i-propanol.
20 The solution was concentrated *in vacuo* to obtain a foam 0.42 g (39%) which was dried. Anal. Calcd for C₇H₁₇N₃ · 2 HCl · 0.15 H₂O · 0.15 i-PrOH: C, 39.27; H, 9.07; N, 18.44; Cl, 31.12. Found: C, 39.25; H, 9.53; N, 18.04; Cl, 31.52.

25

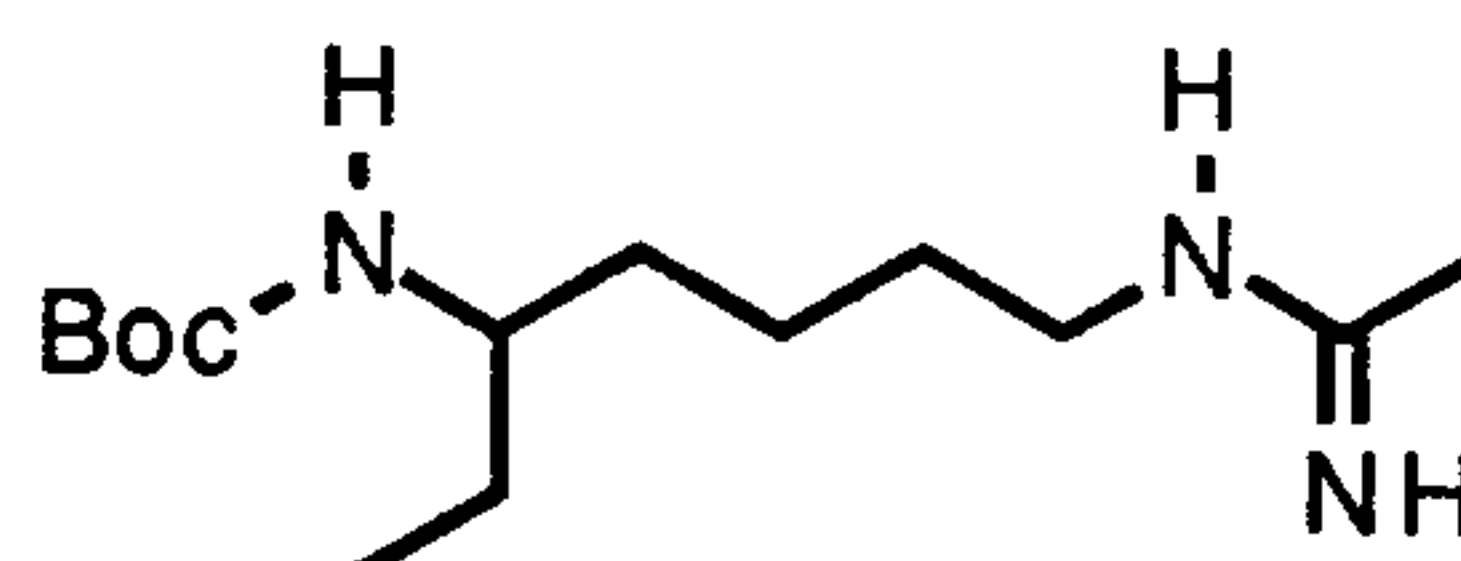
Example 5**N1-(1-iminoethyl)-1,5-heptanediamine****5**

41

**5a**

5

5a. A solution of **3d** (500 mg, 1.38 mmol) in AcOH/EtOH was treated with H₂ (5 psi) over Pd black for 21 h. The reaction mixture was filtered and concentrated *in vacuo*. The residue was dissolved in CH₂Cl₂ (125 mL) and extracted with NaOH (1 M), dried over Na₂SO₄, filtered, and concentrated *in vacuo* to yield 0.32 g of a white gum.

**5b**

15

5b. A solution of **5a** (0.29 g, 1.26 mmol) and ethyl acetimidate hydrochloride (0.156 g, 1.3 mmol) in EtOH (15 mL) was stirred for 18 h. The reaction solution was concentrated *in vacuo* to yield 0.40 g of a white gum. This material was used in the next step without further purification.

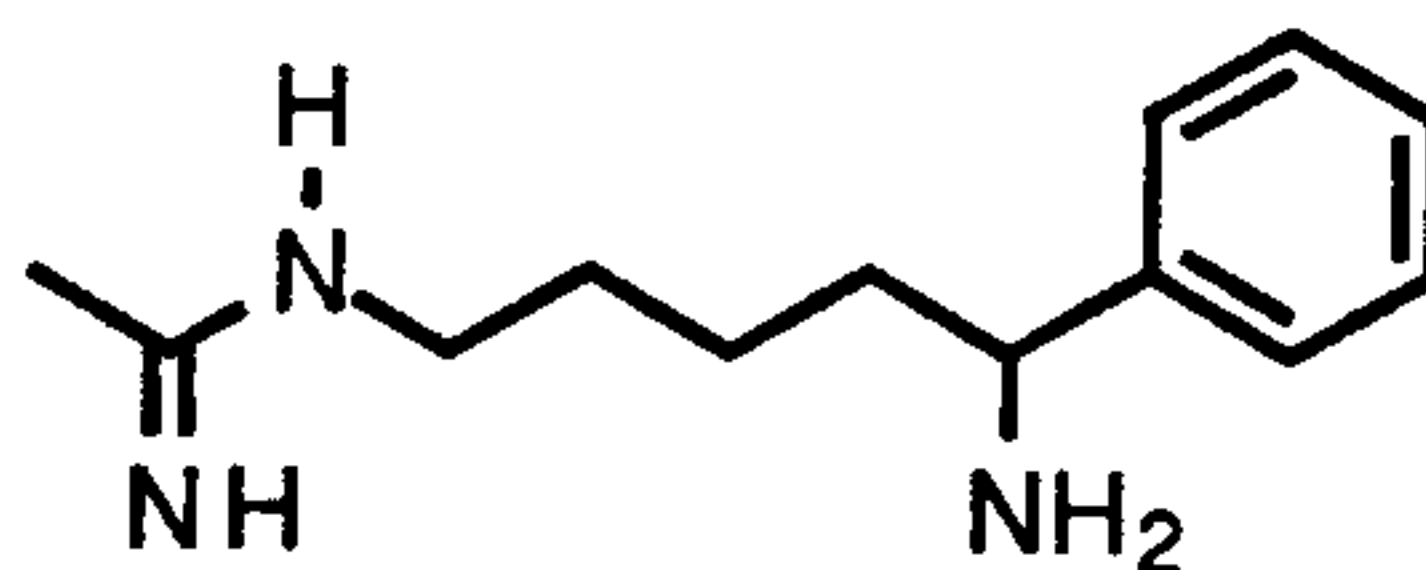
5

25

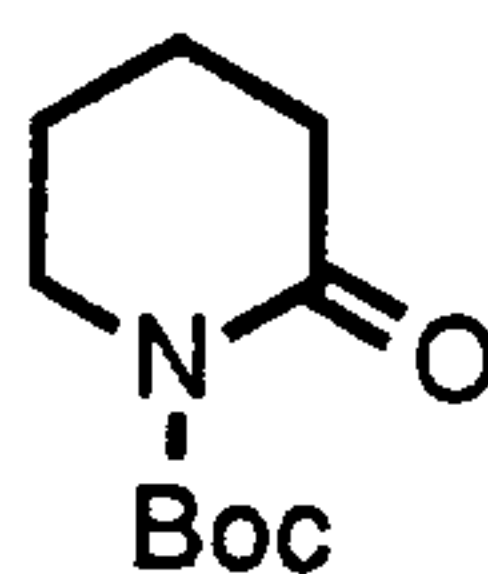
5. To a stirred solution of **5b** (0.40 g, 1.26 mmol) in AcOH (glacial, 10 mL) was added HCl (6.95 M in dioxane, 14 mmol). The resulting solution was stirred for 2 h. The solution was concentrated *in vacuo* to yield 0.41 g of a gum. This material was purified by reversed phase HPLC on a C-18

42

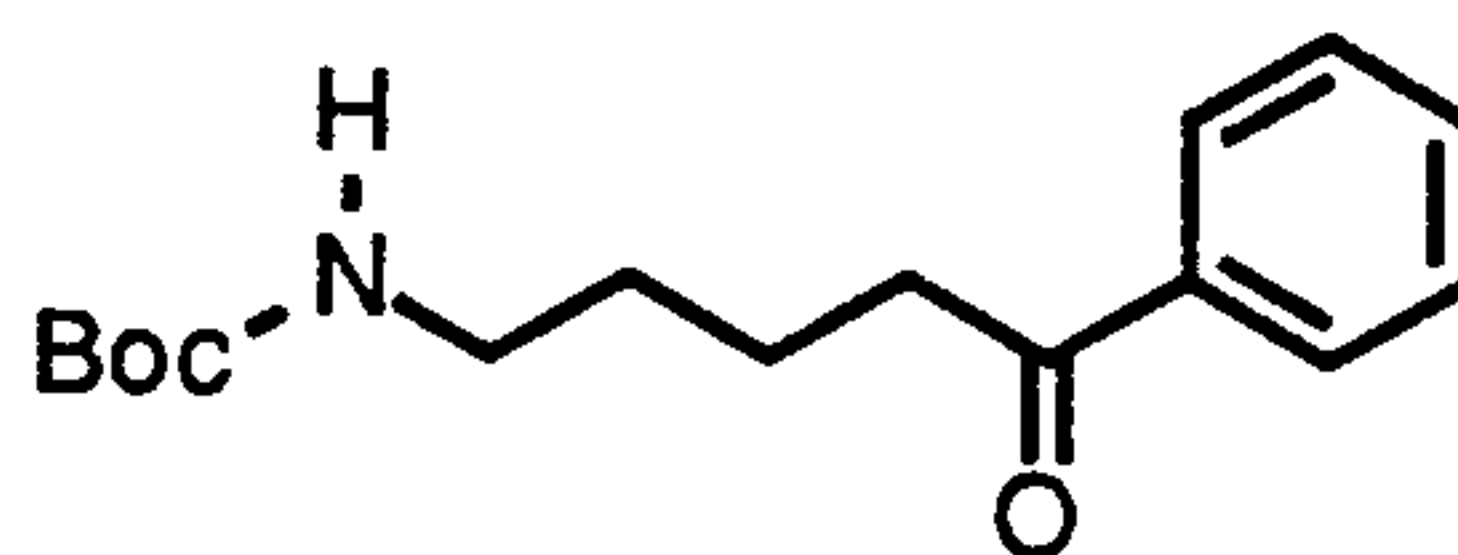
support (7:3 CH₃CN:H₂O) to yield 95 mg of clean product as a glass. HRMS calcd for C₉H₂₂N₃: 172.1814. Found: 172.1809.

Example 6**5 N1-(1-iminoethyl)-5-phenyl-1,5-pentanediamine****6**

10

**6a**

6a. The reaction for example **4a** was repeated on a 0.4 mol scale with valerolactam. The yield of the reaction was quantitative.

**6b**

20

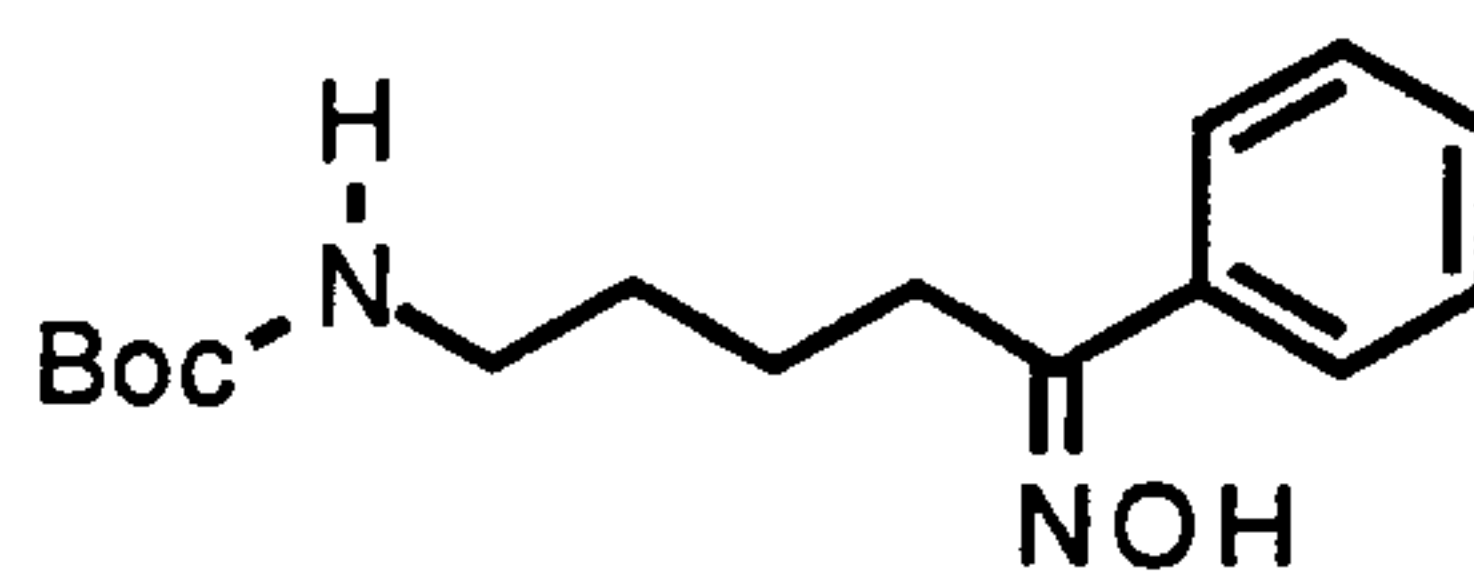
6b. A solution of **6a** (5 g, 25 mmol) in THF (125 mL) at -78°C was treated with phenylmagnesium bromide (9.5 mL, 3.0 M). The resulting solution was stirred at -72°C for 35 min then poured onto brine (satd) and extracted with Et₂O. The organic solution was dried, filtered, and concentrated in vacuo to yield 6.42 g of an oil. The product was chromatographed and recrystallized from hexane to yield 3.78

25

43

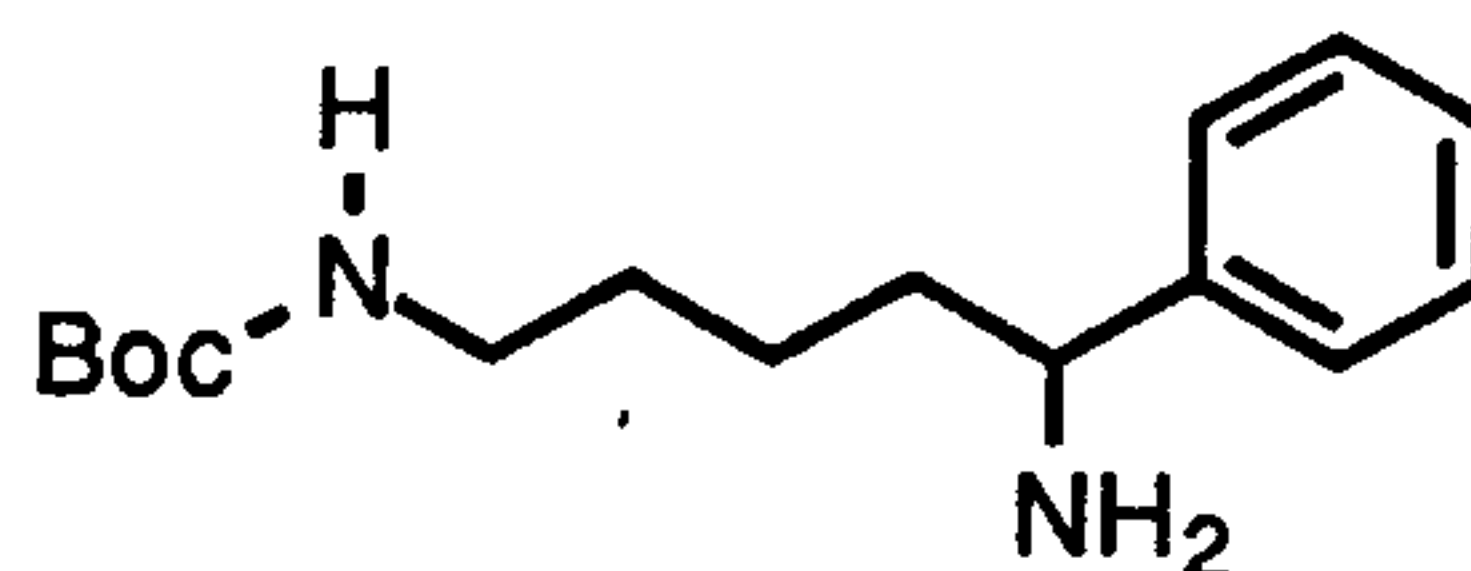
g (55%) of a white solid. Anal. Calcd for $C_{16}H_{23}NO_3$: C, 69.28; H, 8.36; N, 5.05. Found: C, 69.30; H, 8.84; N, 4.95.

5

**6c**

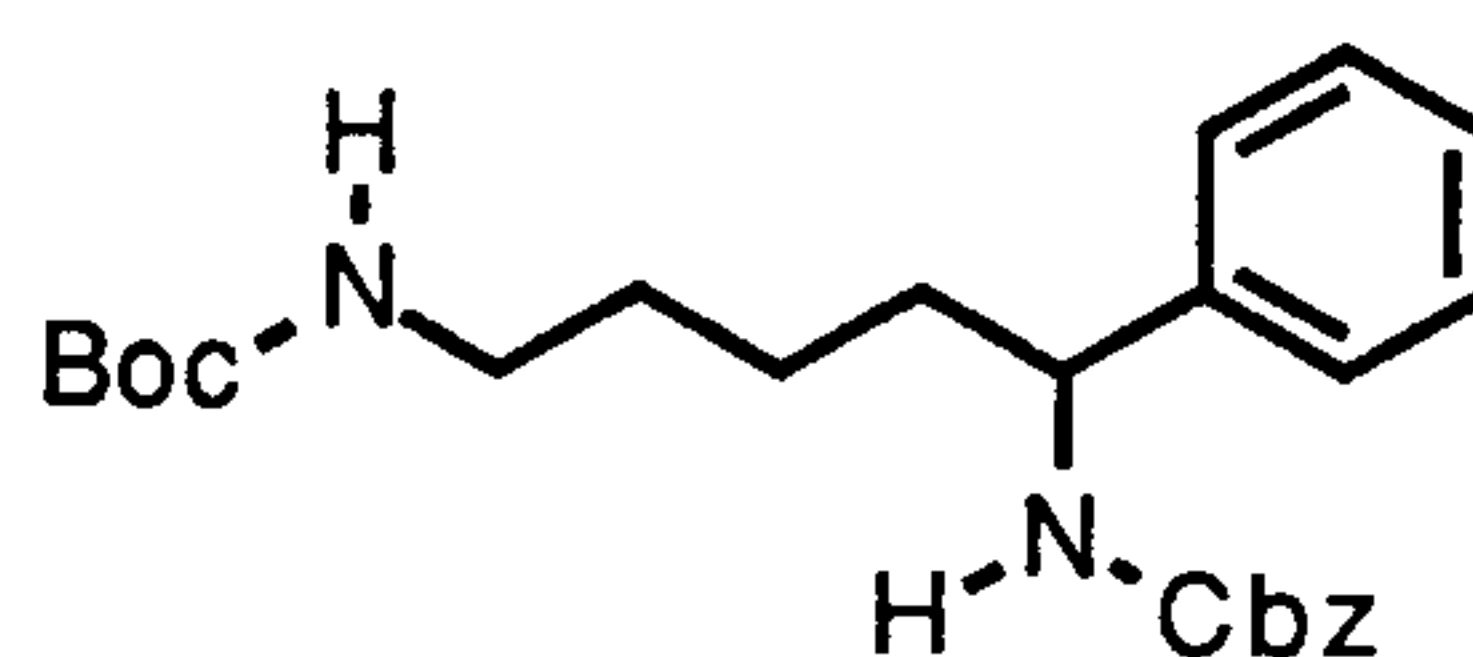
6c. A stirred suspension of **6b** (0.50 g, 1.8 mmol) in EtOH (3 mL) was treated with a solution of hydroxylamine hydrochloride (0.25 g, 3.6 mmol), sodium acetate (0.25 g, 3.8 mmol) in H_2O (3 mL). The solution was refluxed for 4.5 h, during which time a solution formed. After cooling to room temperature H_2O (50 mL) was added and the mixture extracted with $CHCl_3$ (3 x 30 mL). The $CHCl_3$ extracts were combined, dried, filtered, and concentrated *in vacuo* to yield 420 mg (80%) of a white solid. Anal. Calcd for $C_{16}H_{24}N_2O_3$: C, 65.73; H, 8.27; N, 9.50. Found: C, 65.79; H, 8.79; N, 9.53.

20

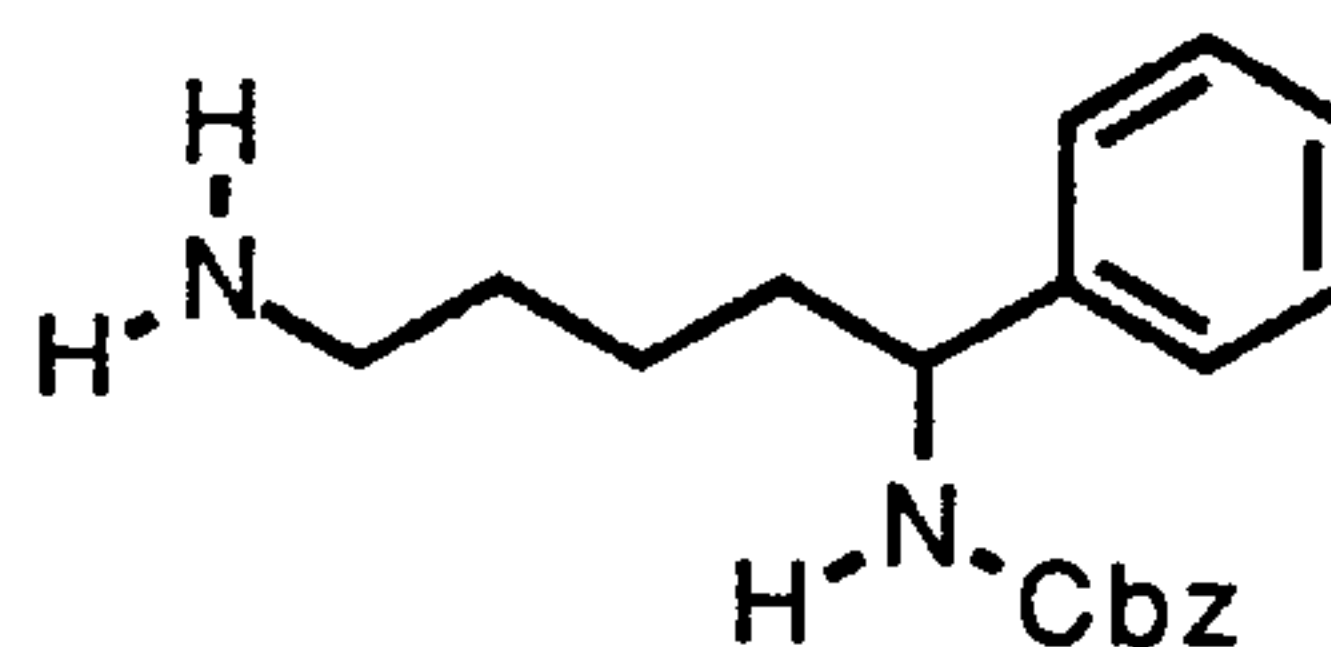
**6d**

6d. A solution of **6c** (3.54 g, 24 mmol) in EtOH was treated with H_2 (5 psi) over 10% Pd/C for 24 h. The reaction mixture was filtered and concentrated *in vacuo* to yield 2.61 g (77%) of a colorless oil. Anal. Calcd for $C_{16}H_{26}N_2O_2$: 0.4 EtOH: C, 67.98; H, 9.64; N, 9.44. Found: C, 68.19; H, 9.38; N, 9.11.

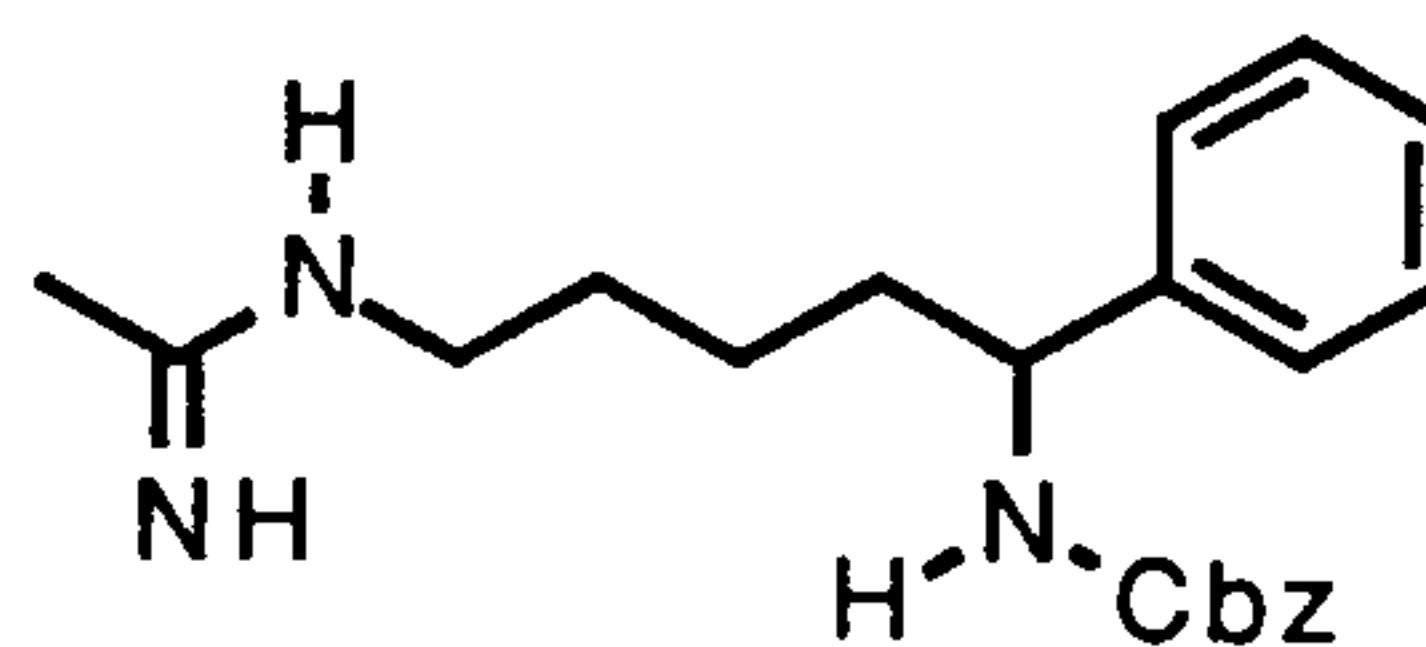
44

**6e**

6e. To a solution of **6d** (2.1 g, 7.54 mmol) in EtOAc (100 mL) in a separatory funnel was added NaOH (1 M, 60 mL) and benzylchloroformate (1.93 g, 11.31 mmol). The mixture was shaken for several minutes and the layers separated. The EtOAc solution was extracted with brine, dried, filtered, and concentrated *in vacuo* to yield an oil. The oil was chromatographed to yield 2.34 g (75%) of a white solid.

**6f**

6f. A solution of **6e** (2.0 g, 4.85 mmol) in CH₂Cl₂ (25 mL) at 0°C was treated with TFA (20 mL) and allowed to warm to room temperature over 1.5 h. The solution was concentrated *in vacuo* to yield a yellow oil. The oil was dissolved in CHCl₃ and extracted with NaOH (1 M) and brine (satd), dried over Na₂SO₄, filtered, and concentrated *in vacuo* to yield 1.35 g (89%) of a gum.

**6g**

6g. A solution of **6f** (1.3 g, 4.16 mmol) and ethyl acetimidate hydrochloride (0.533 g, 4.2 mmol) in EtOH (20

45

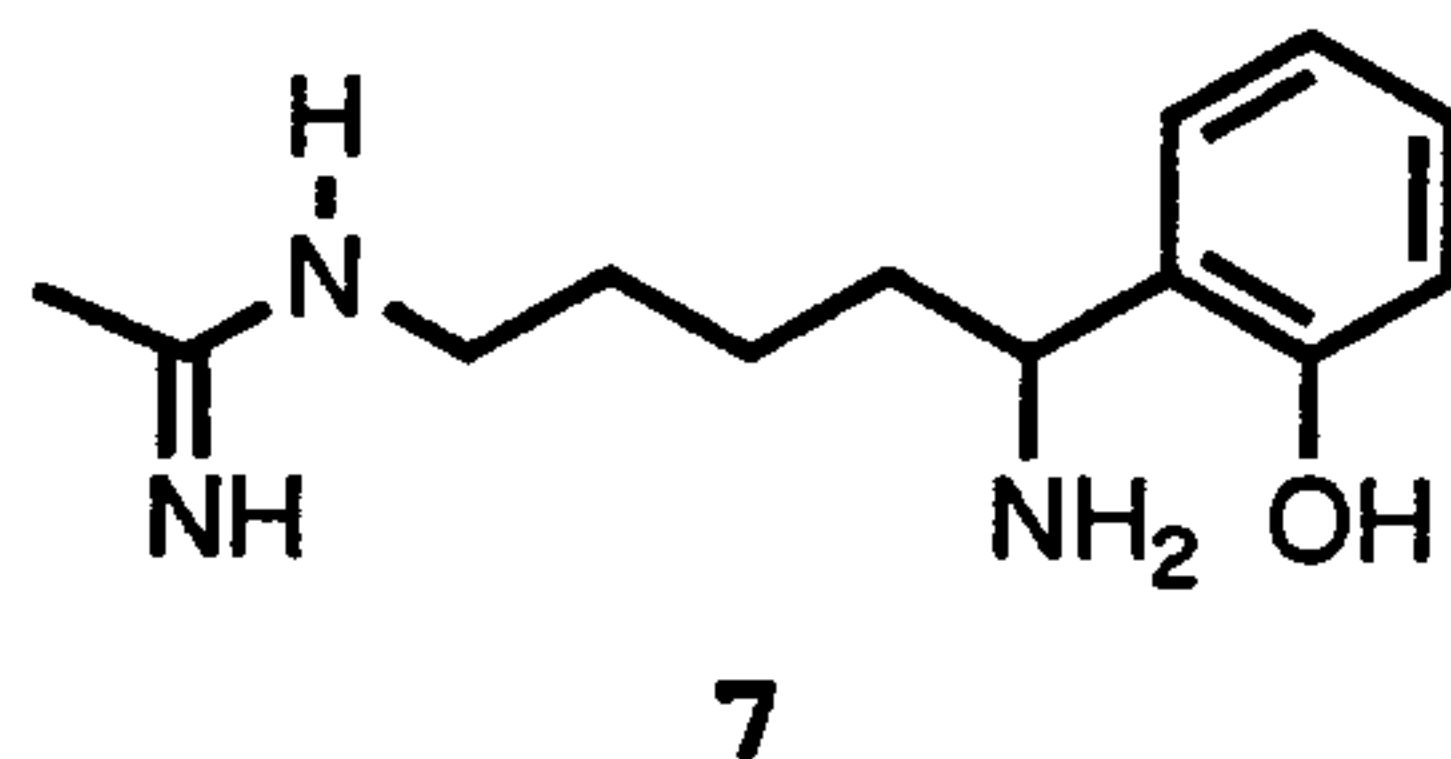
mL) was stirred for 18 h. The reaction solution was concentrated *in vacuo* to yield 1.65 g of a white foam. This material was purified by reversed phase HPLC to yield 1.09 g of a foam. Anal. Calcd for $C_{21}H_{27}N_3O_2 \cdot 1HCl \cdot 0.75 H_2O$: C, 62.52; H, 7.37; N, 10.42. Found: C, 62.82; H, 7.05; N, 10.12.

6

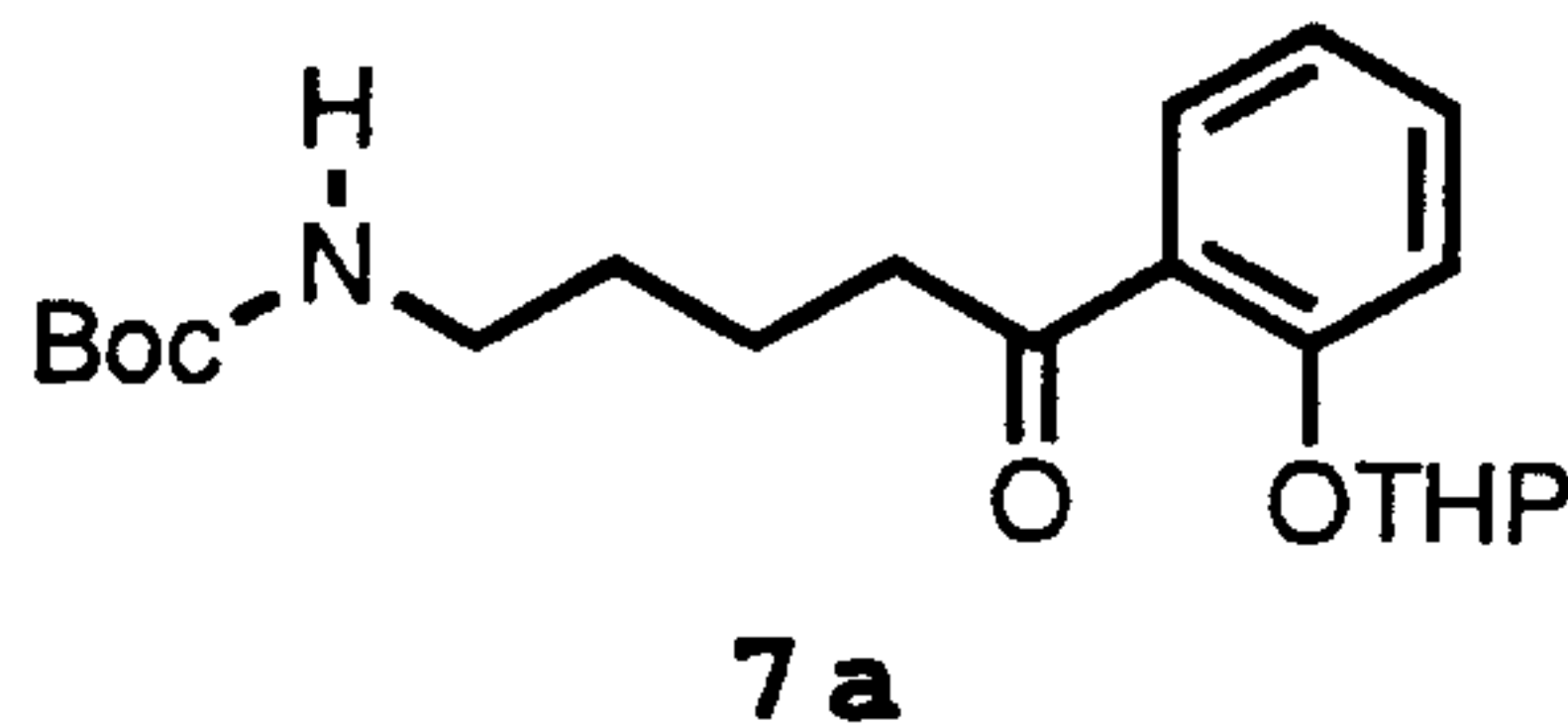
6. A solution of **6g** (0.94 g, 2.41 mmol) in AcOH was treated with H_2 (5 psi) over Pd black for 20 h. The reaction mixture was filtered and concentrated *in vacuo*. The residue was dissolved in EtOH (10 mL) and HCl/Dioxane (1 mL, 5.8 M) added and concentrated *in vacuo* to yield 0.52 g (74%) of a white powder. Anal. Calcd for $C_{13}H_{21}N_2O_2 \cdot 2HCl \cdot 0.75 H_2O \cdot 0.2 EtOH$: C, 51.10; H, 8.22; N, 13.34; Cl, 22.51. Found: C, 50.98; H, 7.82; N, 13.66; Cl, 22.20.

Example 7

N-[5-amino-5-(2-hydroxyphenyl)pentyl]ethanimidamide



25



7a. The reaction for example **6b** was repeated on a 25 mmol scale with 2-(tetrahydropyran-2-yloxy)phenyllithium. The 2-(tetrahydropyran-2-yloxy)phenyllithium was prepared

46

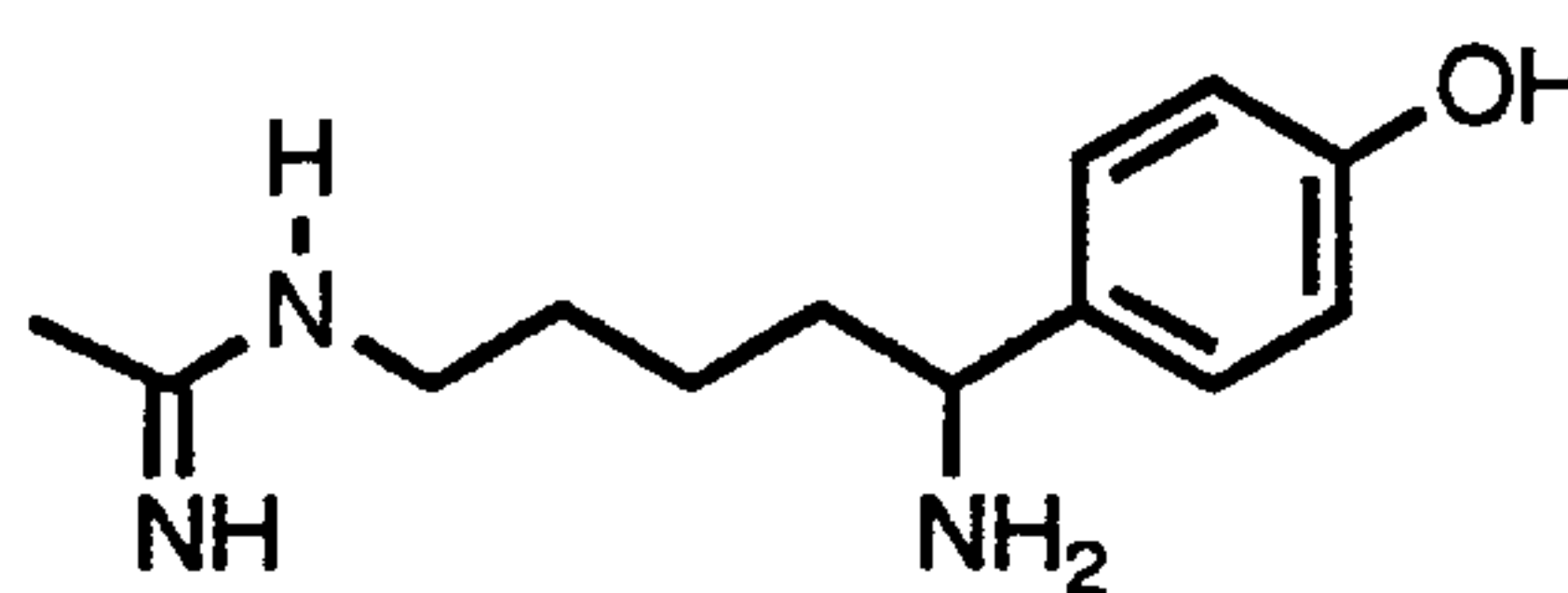
from 2-(tetrahydropyran-2-yloxy)phenyl bromide and n-BuLi in THF at -78°C. The crude product was chromatographed to yield 4.07 g (43%) of a yellow oil.

5

7

7. Example 7 is prepared in the same manner as described for example 6.

10

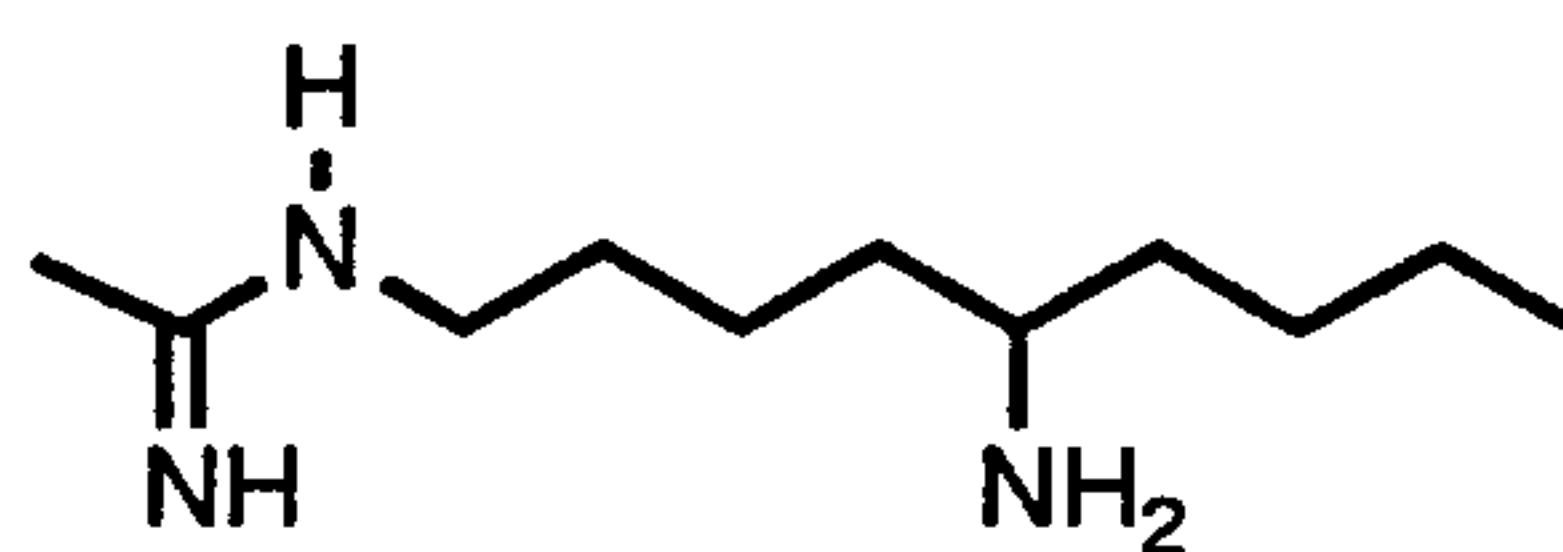
Example 8**N-[5-amino-5-(4-hydroxyphenyl)pentyl]ethanimidamide**

8

15

8. Example 8 is prepared in the same manner as described for example 6 starting with 4-(tetrahydropyran-2-yloxy)phenyllithium.

20

Example 9**N-(5-aminononyl)ethanimidamide**

9

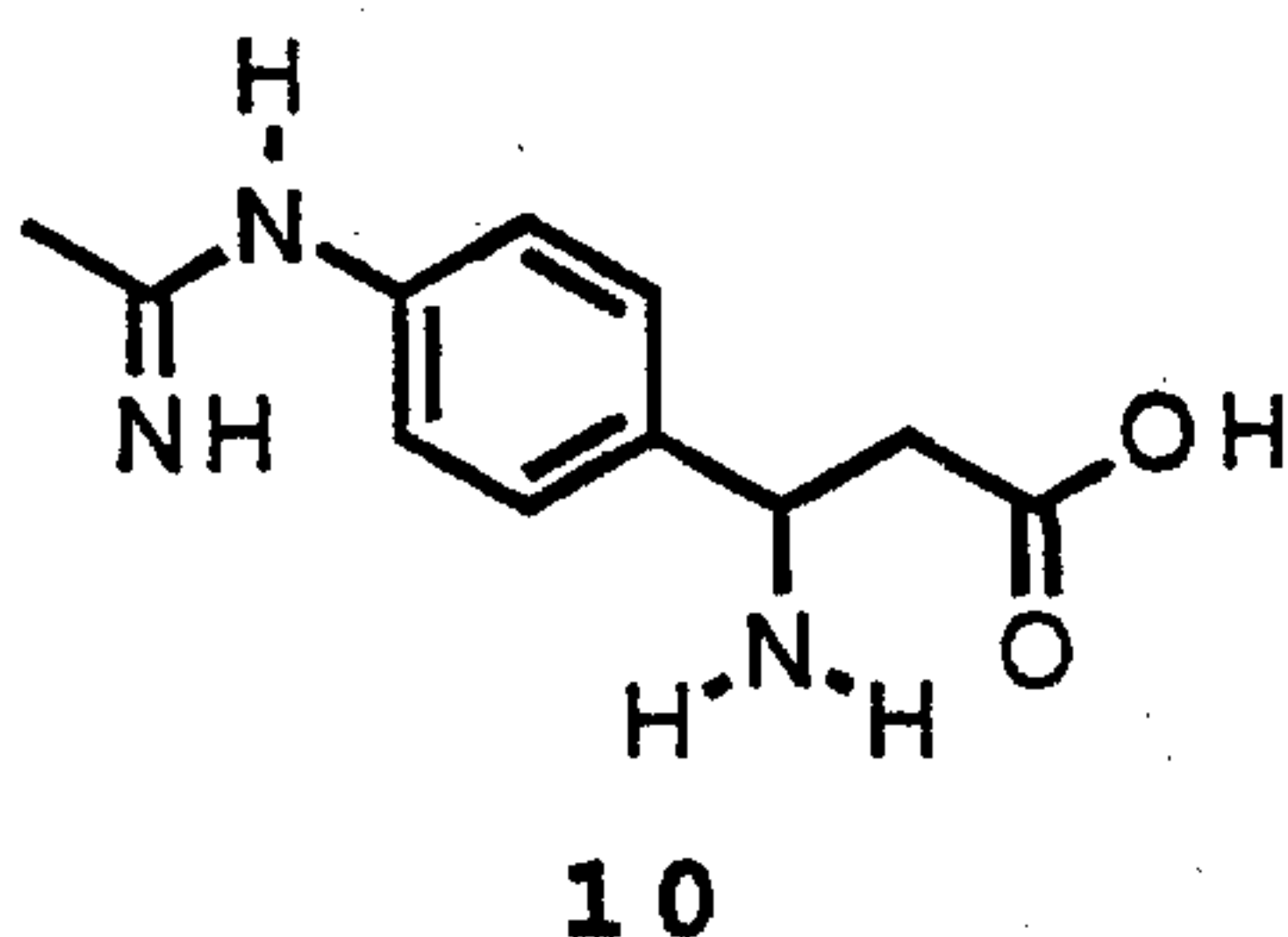
25

9. Example 9 is prepared in the same manner as described for example 6 starting with n-butyllithium.

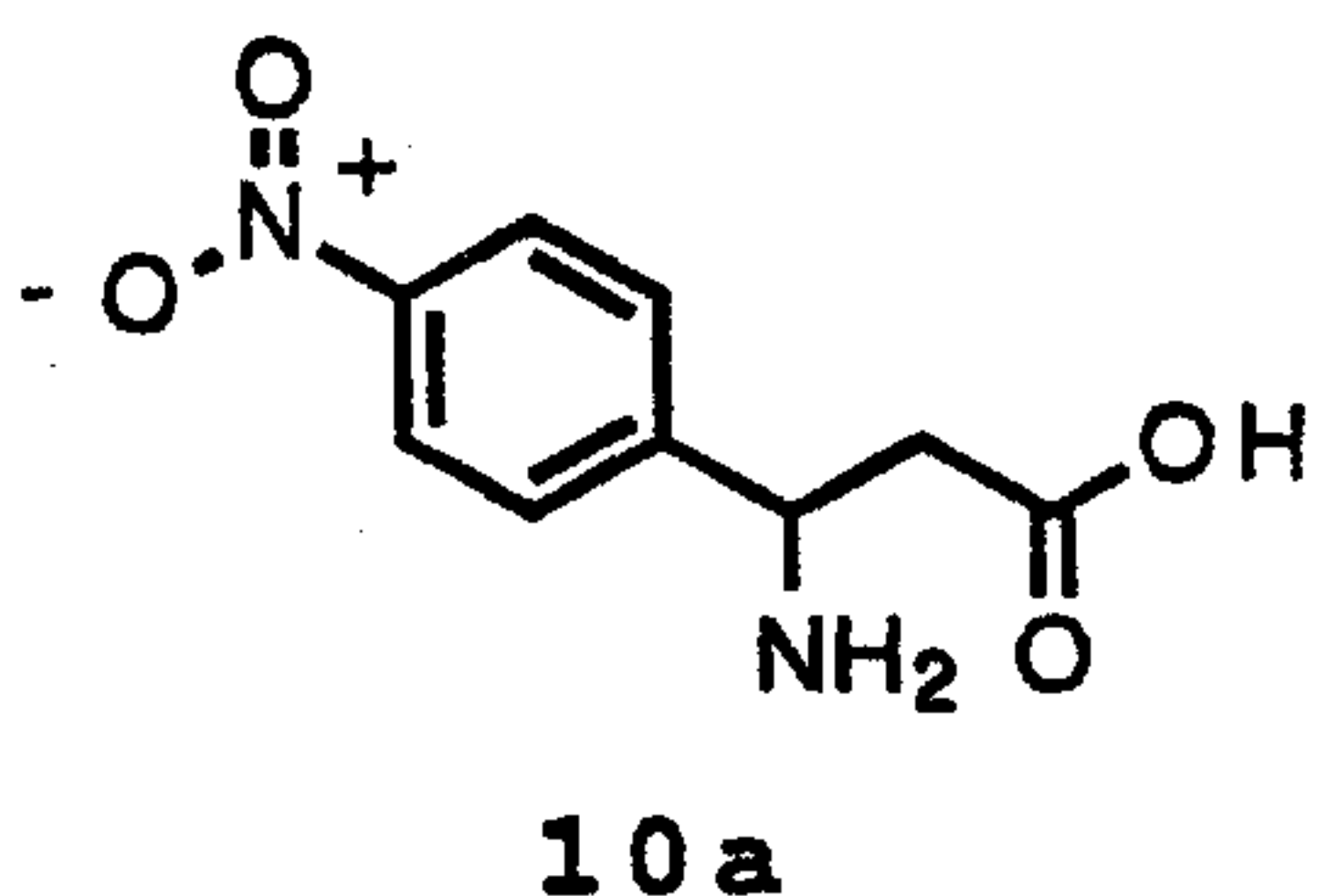
30

Example 10 **β -amino-4-[(1-iminoethyl)amino]benzenepropanoic acid, dihydrochloride hydrate**

47

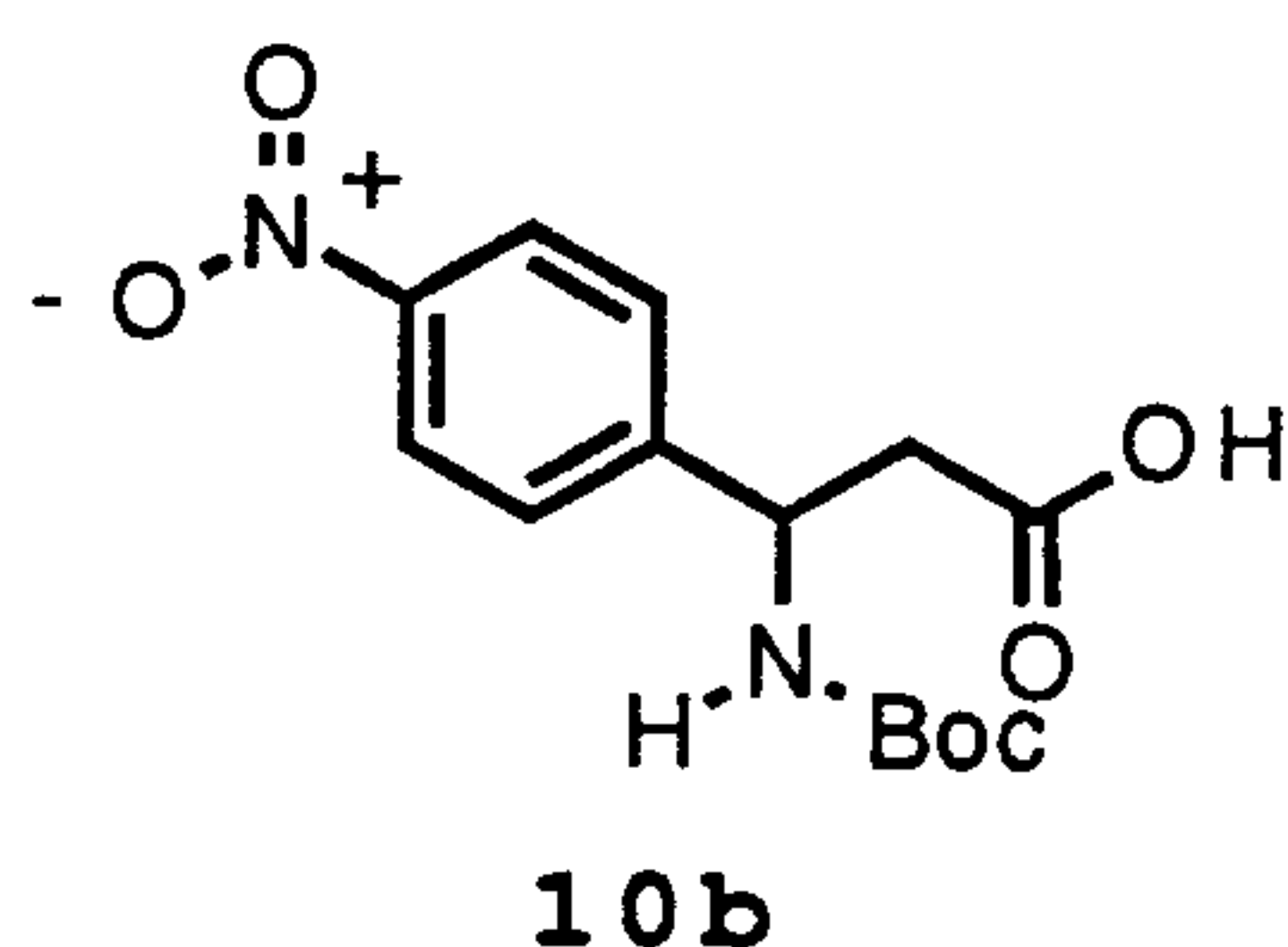


5

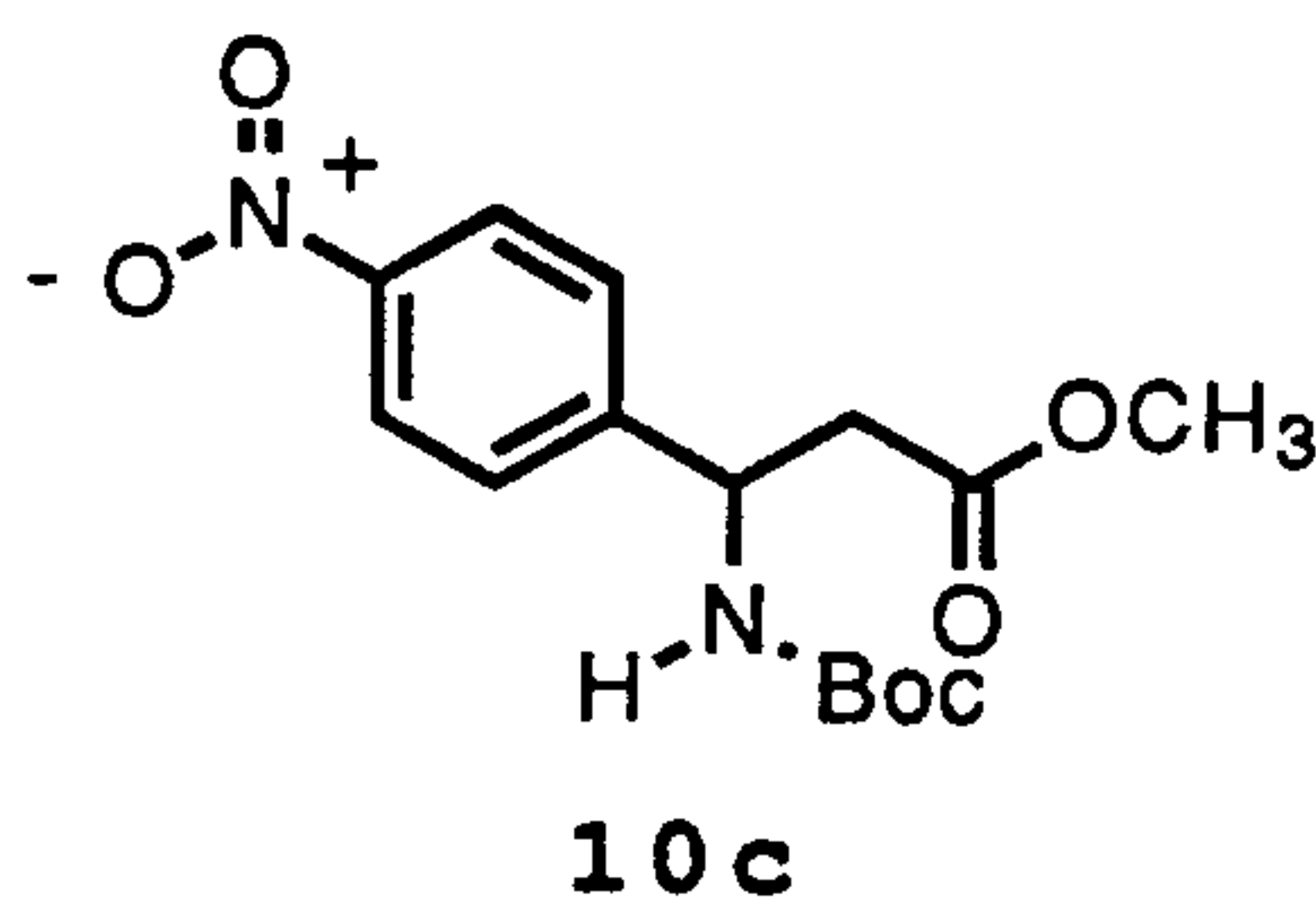


- 10 **10a.** A mixture of 4-nitrobenzaldehyde (39 g, 0.26 mol),
malonic acid (30.5 g, 0.29 mol) and ammonium acetate (49 g,
0.64 mol) in AcOH was heated at 100°C for 5 h, followed by
the addition of HCl (25%, 200 mL) and continued heating at
100°C for 5 additional hours. The reaction mixture was
15 cooled to room temperature and H₂O (300 mL) added, the
resulting precipitate was filtered and washed with H₂O (100
mL). The filtrate and wash were combined and concentrated
in vacuo, followed by the addition of H₂O (300 mL). The
resulting mixture was heated on a steam bath, decolorized
20 with carbon and filtered through celite™. The pH of the
solution was adjusted to 7 with NH₄OH (conc.) and the
resulting precipitate collected. The solid was washed with
H₂O (100 mL), methanol:H₂O (1:1, 100 mL), methanol:Et₂O
(1:1, 100 mL) and Et₂O (100 mL). The solid was dried in
25 vacuo to yield 29.8 g of a yellow solid.

48

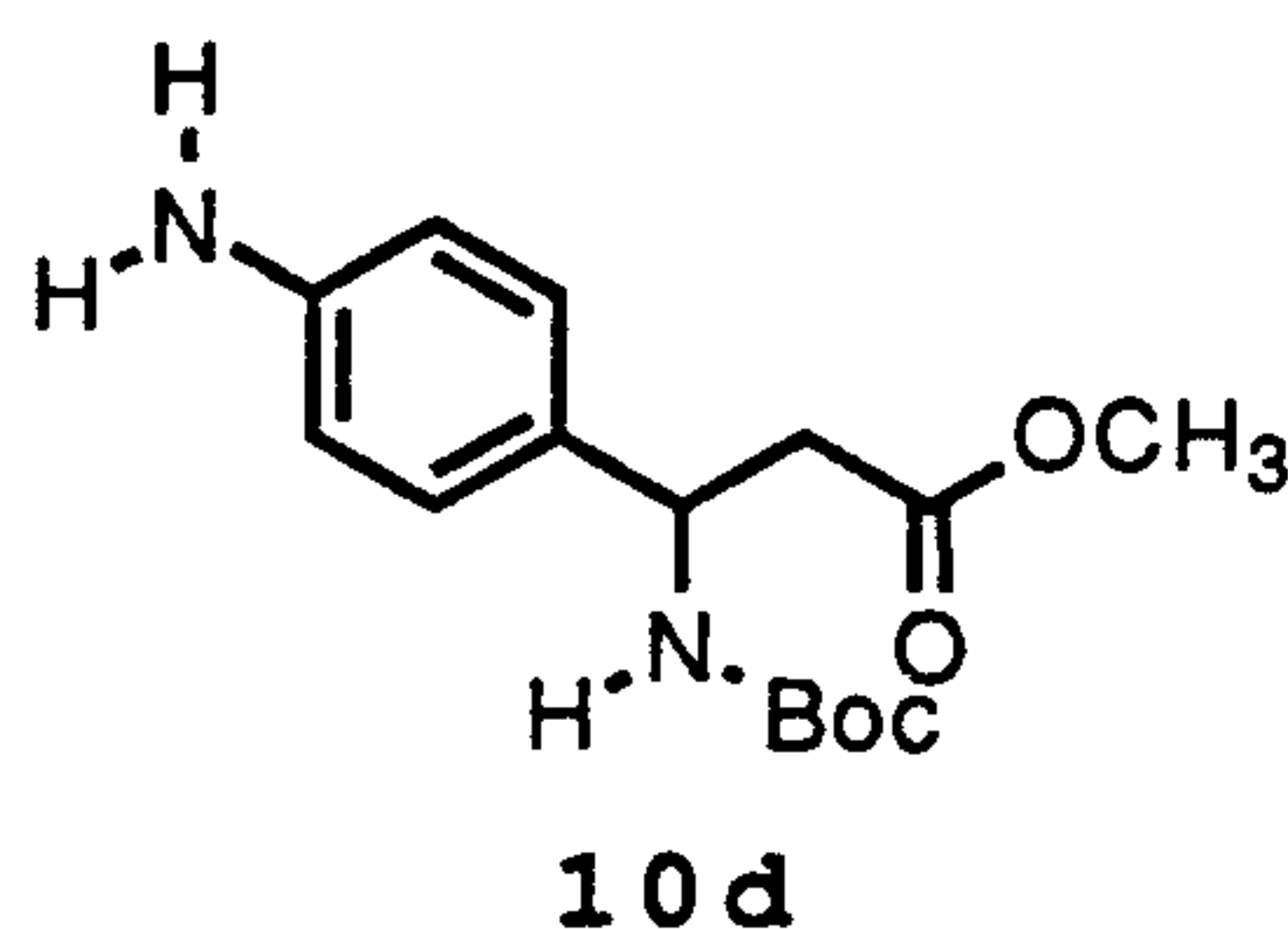


5 **10b.** A solution of **10a** (5.0 g, 24 mmol), di-*t*-butyl dicarbonate (5.7 g, 26 mmol) in NaOH (1 M, 50 mL) and dioxane (50 mL) was stirred for 4 h. The solvent was concentrated to 50 mL to which was added EtOAc (400 mL) and KHSO₄ (1M, 75 mL). The layers were separated and the organic layer was washed with brine (satd.), dried, 10 filtered, and concentrated *in vacuo* to yield 8.5 g of a yellow foam.



15

10c. Example **10c** was prepared in the same manner as **3a**.

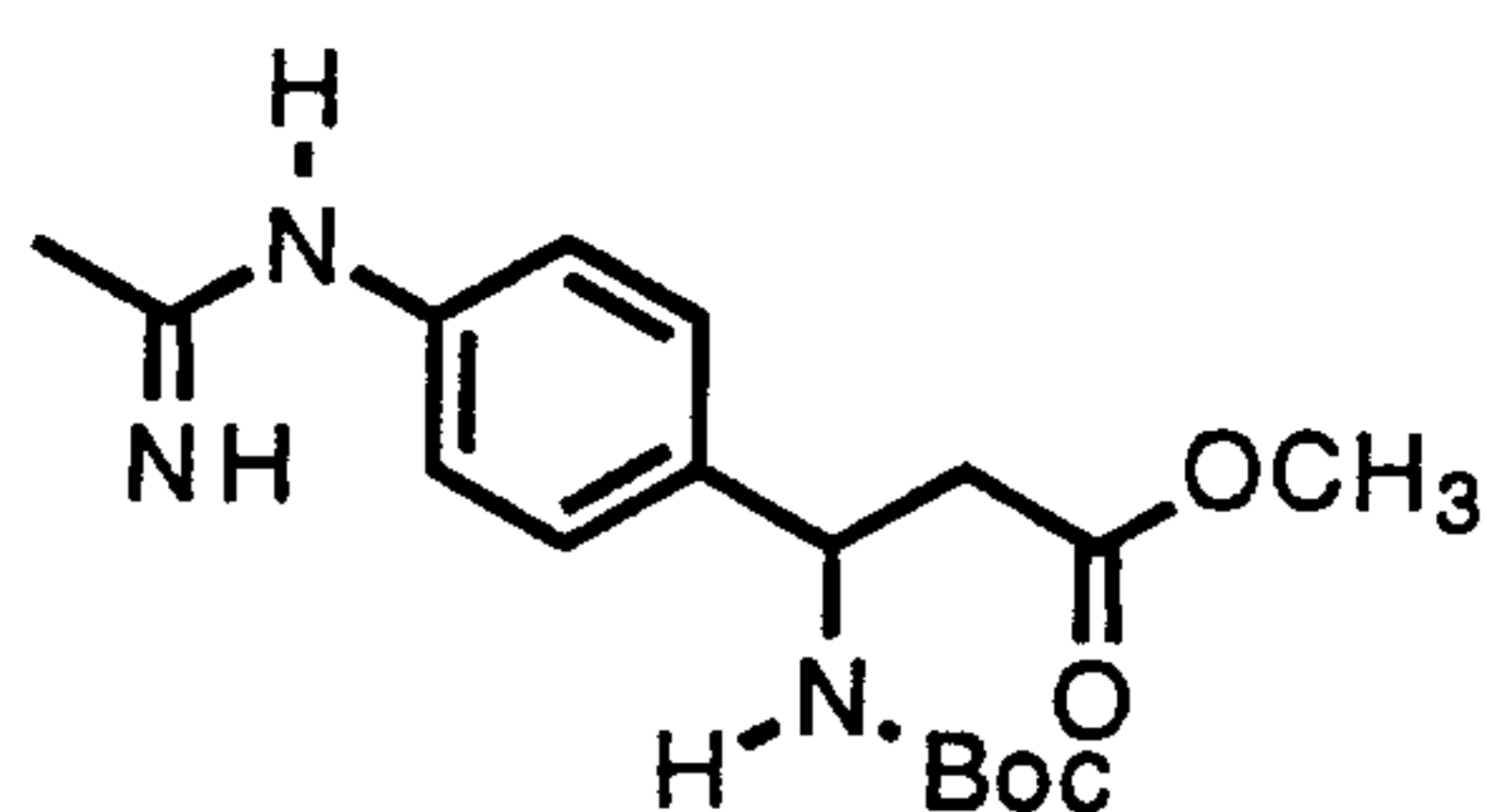


20

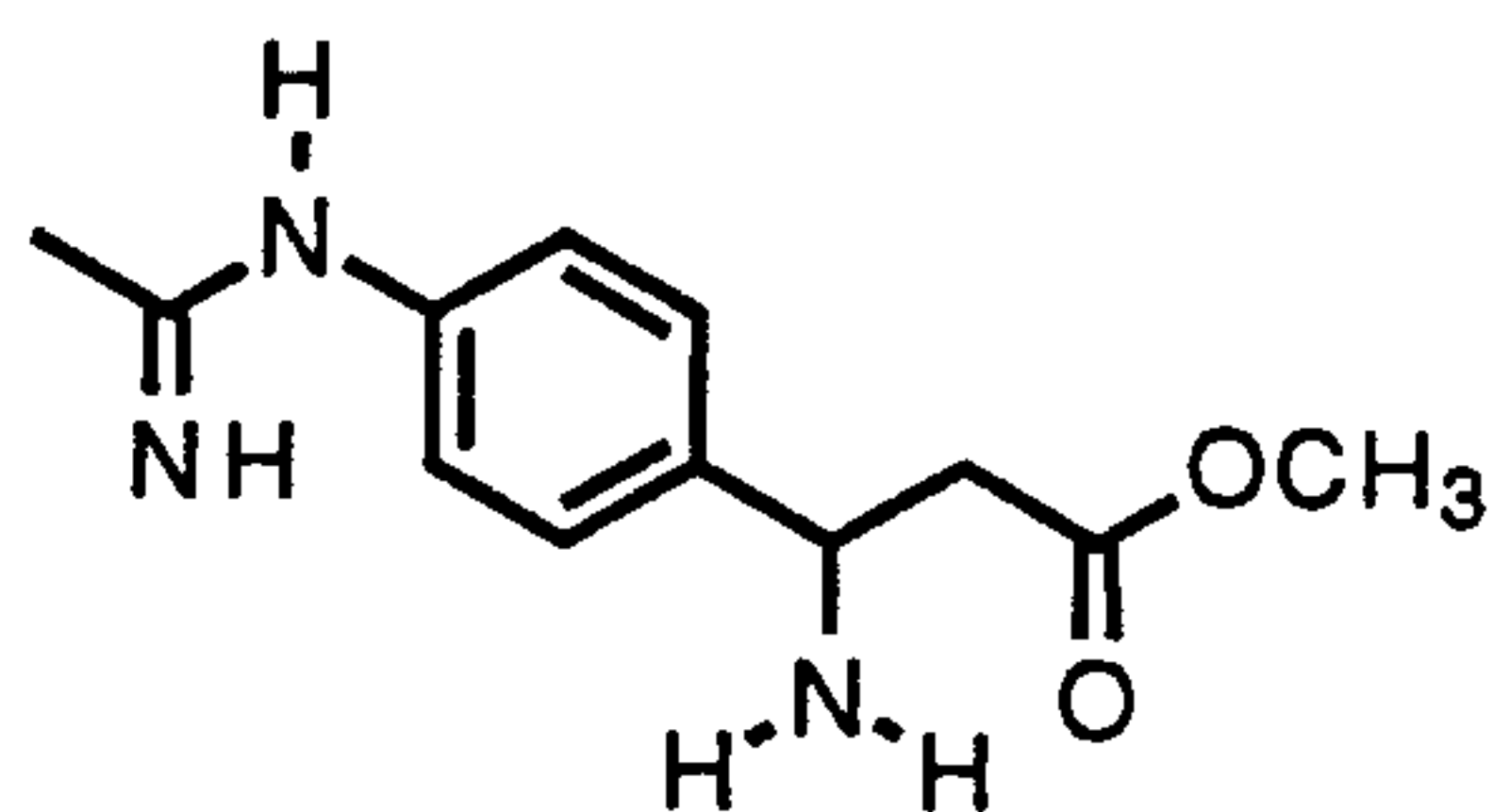
10d. A solution of **10c** (8 mmol) in EtOH was treated with H₂ (5 psi) over 10% Pd/C for 18 h. The reaction mixture was filtered and concentrated *in vacuo* to yield the product.

25

49

**10e**

10e. The reaction for example **6g** was repeated using **10d**
5 on a 5 mmol scale.

**10f**

10 **10f.** A solution of **10e** (890 mg, 2.4 mmol) in CH₂Cl₂ : TFA
(1:1, 50 mL) was stirred at 0°C for 15 min. The solvent was
removed in vacuo and the residue was dissolved in water (100
mL) and the extracted with EA. The pH of the aqueous
solution was adjusted to 11 with K₂CO₃ and extracted with
15 CH₂Cl₂. The CH₂Cl₂ extracts were dried (Na₂SO₄) and
concentrated. The residue was chromatographed on silica gel
(9:1:1; ACN:H₂O:AcOH) to to yield **10f** 50 mg (5 %) as a
foam. Anal. Calcd for C₁₂H₁₇N₃O₂·3 AcOH·1 H₂O: C, 49.87; H,
7.21; N, 9.69. Found: C, 49.61; H, 6.96; N, 9.78. HRMS
20 calcd.: 235.1320. Found: 235.1320.

10

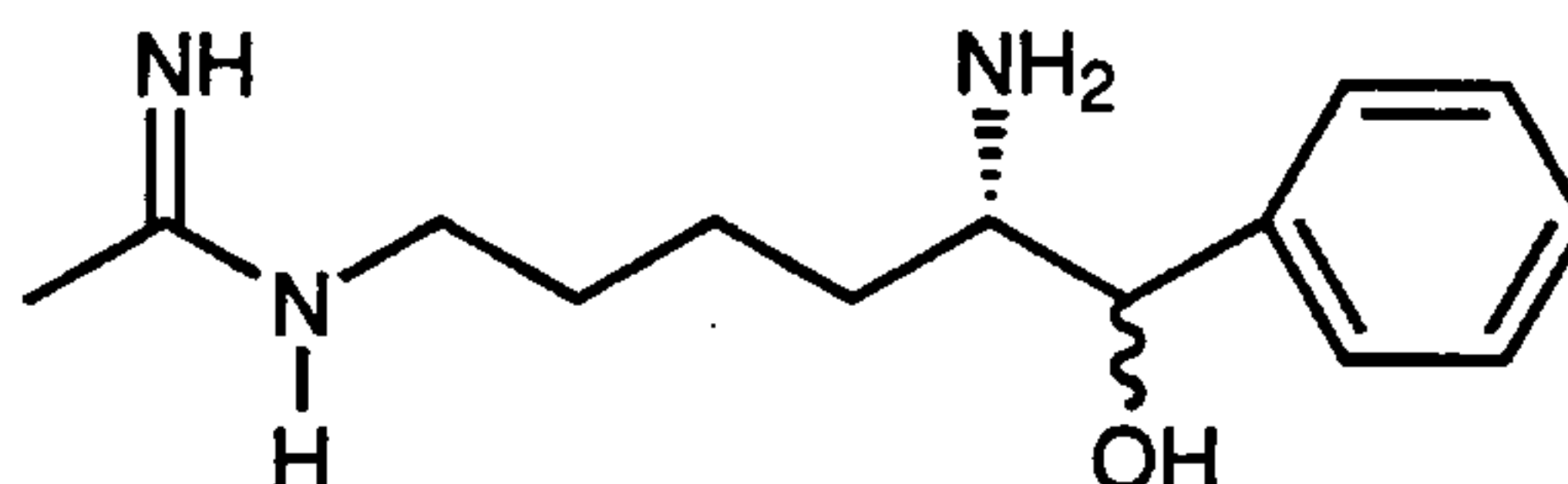
25 **10.** A solution of **10f** (20 mg, .5 mmol) in HCl (2N, 5 mL)
was refluxed for 1 h. The solvent was removed via
lyophilization to yield **10** 24 mg as a foam. Anal. Calcd
for C₁₁H₁₅N₃O₂·2.3 HCl·0.6 H₂O: C, 41.82; H, 5.90; N, 13.30.

50

Example 11

**α -[1-amino-5-[(1-iminoethyl)amino]pentyl]benzenemethanol
hydrochloride dihydrate**

5



10

N- α -Z-N- ϵ -Boc-L-Lys-N(OMe)Me (11a)

11a. To a stirring solution of N- α -Z- ϵ -Boc-L-Lys (5 g, 13.8 mmol), N,O-dimethylhydroxylamine HCl (3.9 g, 39.5 mmol), 1-hydroxybenzotriazole hydrate (2 g, 14.5 mmol), and triethylamine (13.2 g, 17 mL, 130 mmol) in 75 mL of dimethylformamide (DMF) cooled in an ice bath was added EDC (2.8 g, 14.5 mmol). After stirring 55 h at ambient temperature, triethylamine hydrochloride was filtered from the reaction mixture and the filtrate was concentrated in vacuum. The residue was distributed between 150 mL of ethyl acetate (EtOAc) and 75 mL of 1M KHSO₄ solution. The layers were separated. The organic layer was washed with 1x 75 mL of saturated KHCO₃ solution and 1x 75 mL of brine and was worked up in the usual manner giving 5.3 g of **11a** (95%).

11b. To a stirring solution of **11a** (1.8 g, 4.26 mmol) and N,N,N,N-tetramethylethylenediamine (1.63 g, 2.12 mL, 14.06 mmol) in 50 mL of dry THF at -72°C was added phenyllithium, 1.8 M solution in cyclohexane, (1.18 g, 7.8 mL, 14.06 mmol). After stirring at the same temperature for 2.5 h, the reaction mixture was added to 50 mL of 1M KHSO₄ solution and

50 mL of EtOAc. The layers were separated, the organic layer was washed with 1x 30 mL of brine and worked up in the usual manner giving 2.8 g of crude product which was purified using column chromatography. The yield of **11b** was 1.3 g (69.5%).

11c. To example **11b** (1.3 g, 2.96 mmol) dissolved in 30 mL of acetic acid was added 3 mL of 5N HCl/dioxane. The reaction was stirred for 20 min. at ambient temperature concentrated under vacuum. The residue was dried, treated with Et₂O, washed with hexane, and dried yielding 1.0 g (90.9%) of **11c**. Anal. calcd. for C₂₀H₂₄N₂O₃·HCl·0.4 H₂O: C, 62.54; H, 6.77; N, 7.29; Cl, 9.23. Found: C, 62.88; H, 6.80; N, 7.22; Cl, 9.18.

11d. 0.5 g of **11c** dissolved in 10 mL of water was neutralized with Na₂CO₃ (pH-9-10), the oil was extracted with 3x 15 mL of EtOAc and the organic solution was worked up in the usual manner giving 0.45 g of **11d**.

11e. A solution of **11d** (0.45 g, 1.32 mmol) and ethyl acetimidate hydrochloride (0.2 g, 1.455 mmol) in 15 mL of ethanol was adjusted to pH 9-10 using a NaOH/ethanol solution. After stirring for 1 h at ambient temperature, the reaction was acidified to pH 2 with 5N HCl/dioxane. The reaction mixture was filtered from NaCl and concentrated in vacuum. The crude product (0.5 g) was purified using reverse phase separation, giving 0.225 g of **11e** (40.91%). Anal. calcd. for C₂₂H₂₇N₃O₃·HCl·0.5 H₂O: C, 61.89; H, 6.85; N, 9.84; Cl, 8.30. Found: C, 61.68; H, 6.50; N, 9.88; Cl, 8.18.

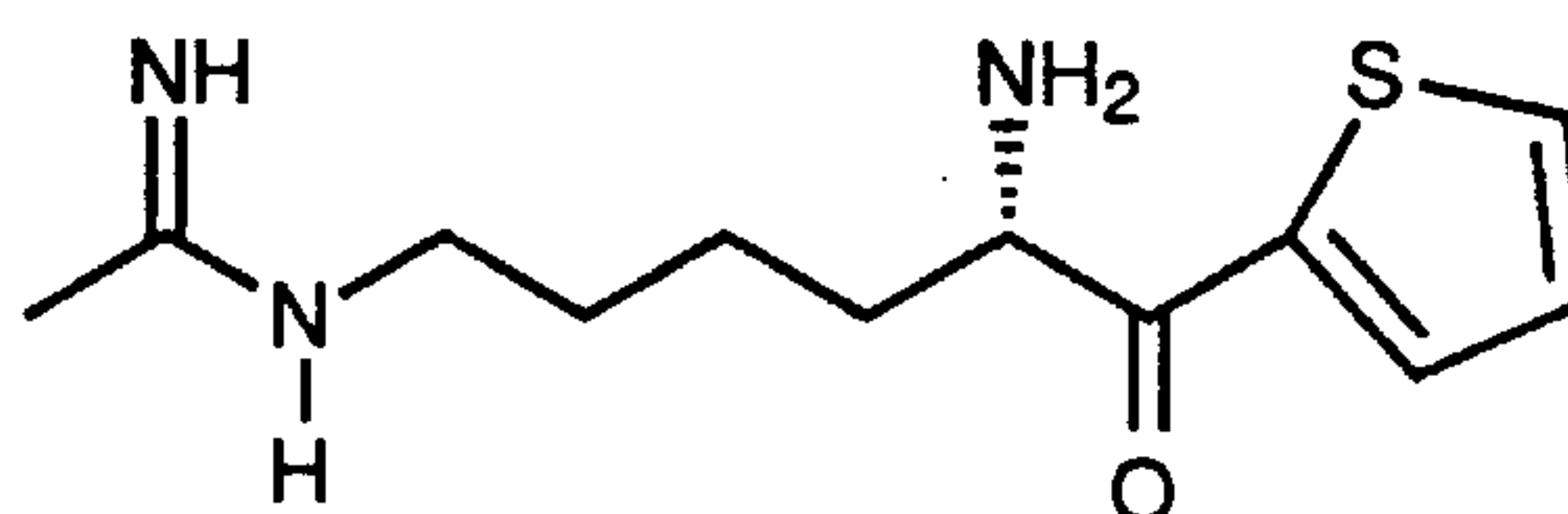
11A, 11B. Example **11e** (.36 g, 0.86 mmol) was reduced under catalytic hydrogenation conditions using Pd black at 60 psi H₂ in 50% EtOH/AcOH solution for 24 h. The yield of the

52

crude product was 0.35 g. After reverse phase separation two products were isolated: the faster running isomer (**11A**) 0.085 g and the slower running isomer 0.1 g (**11B**). Faster running isomer analysis: calcd. for $C_{14}H_{23}N_3O$, $1.5HCl$, $0.4AcOH$, $2H_2O$: C, 48.82; H, 8.33; N, 11.54. Found: C, 48.56; H, 7.79; N, 11.95.

Example 12

N-[5S-amino-6-oxo-6-(2-thienyl)hexyl]ethanimidamide, hydrate

**12**

12a. **12a** was prepared on a 2.84 mmol scale in the same manner as described for **11b** using **11a** and 2-thiophenelithium to yield 0.6 g (47.2%) of **12a** after chromatography. Anal calcd. for: $C_{23}H_{30}N_2O_5S$: C, 61.86; H, 6.77; N, 6.27. Found: C, 61.53; H, 6.91; N, 6.12.

12b. **12b** was prepared from **12a** (0.6 g, 1.34 mmol) in the same manner as for **11c** yielding 0.4 g (85.1%).

12c. **12c** was prepared from **12b** (0.4 g, 1.16 mmol) in the same manner as for **11e** to yield 0.44 g of crude product.

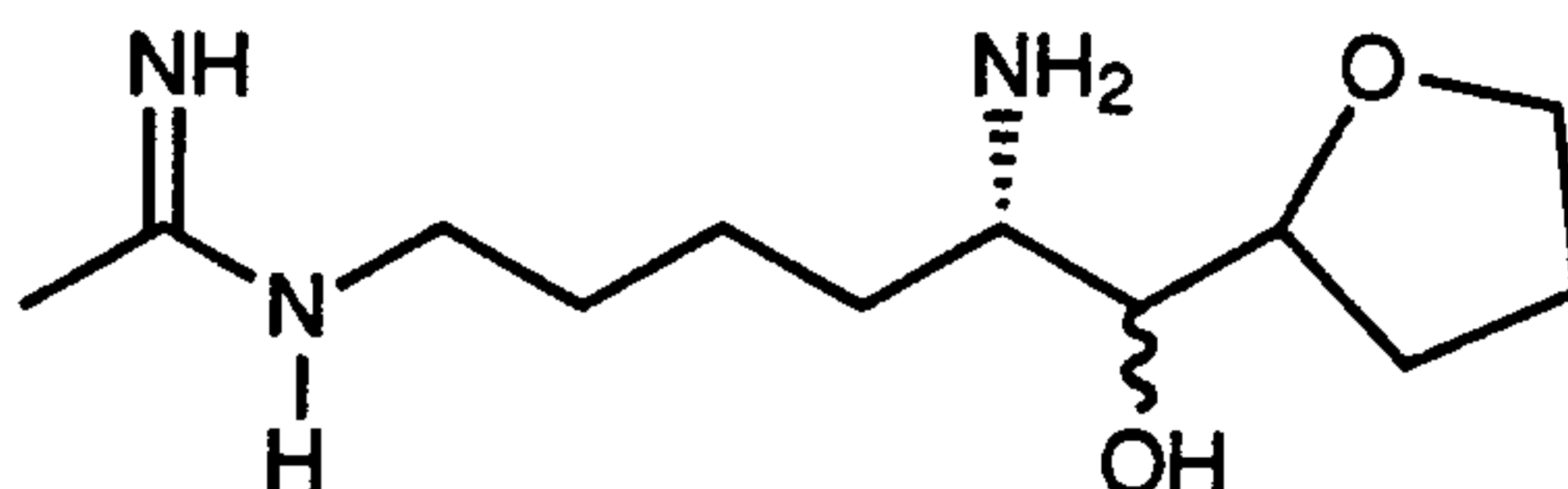
12. To a solution of **12c** (0.44 g, 1.14 mmol) and thioanisole (0.51 g, 0.44 mL, 2.28 mmol) in 10 mL of TFA at 0°C trimethylsilyl trifluoromethanesulfonate (TMSOTf) (0.28 g, 0.27 mL, 2.28 mmol) is added. After mixing at same

53

temperature for 1 h, Et₂O is added. The crude **12** is filtered and is washed with Et₂O.

Example 13

5 **N-[5S-amino-6-hydroxy-6-(tetrahydrofuran-2-yl)hexyl]ethanimidamide**

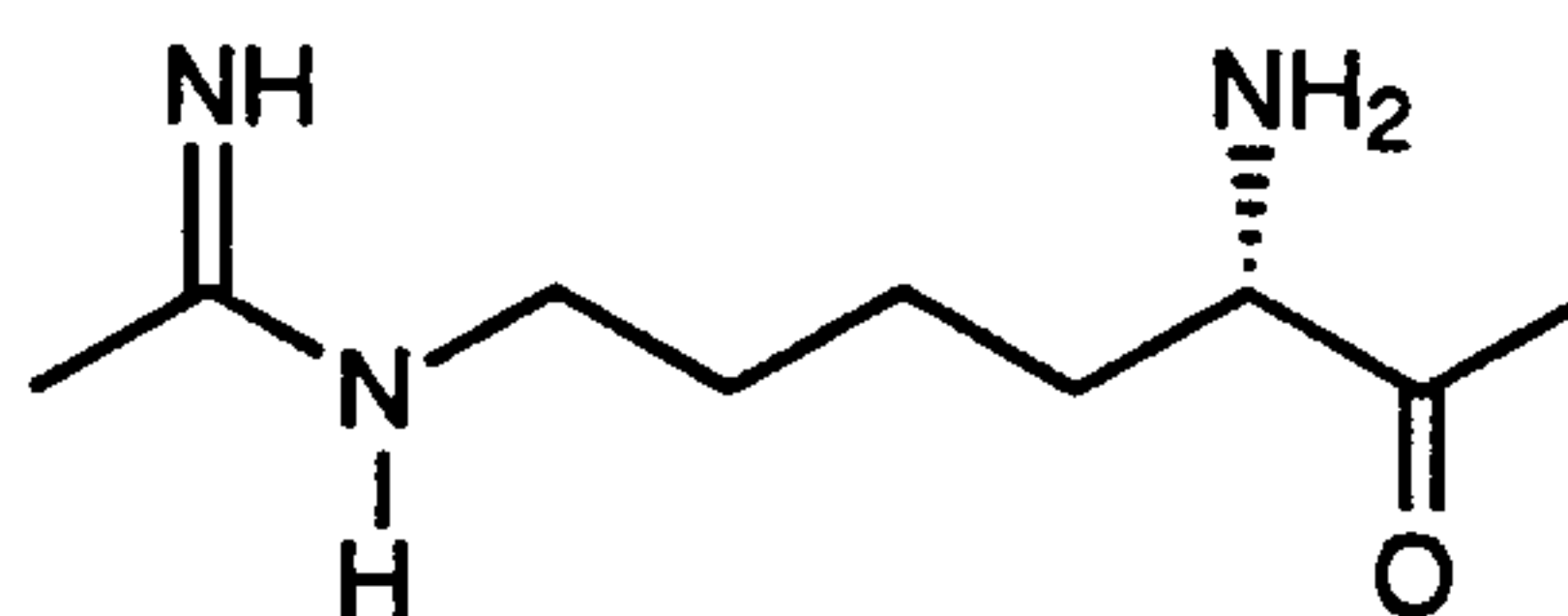
**13**

10

13. Example **13** was prepared in the same manner as example **11** on a 9.2 mmol scale starting with 2-bromofuran.

Example 14

15 **N-(5S-amino-6-oxoheptyl)ethanimidamide, dihydrochloride**

**14**

20

14a. To a stirring solution of **11a** (1.0 g, 2.4 mmol) and N,N,N,N-tetramethylethylenediamine (0.96 g, 1.25 mL, 8.3 mmol) in 30 mL of dry THF at the -72 °C was added methyllithium, 1.4 M solution in Et₂O, (5.9 mL, 8.3 mmol).
25 After stirring at same temperature for 3 h, the reaction mixture was added to 50 mL of 1M KHSO₄ solution and 50 mL of EtOAc at 0 °C. The layers were separated, the organic layer was washed with 1x 30 mL of brine and worked up in the usual manner giving 2.8 g of crude product which was purified

using column chromatography. The yield of **14a** was 0.9 g (55%).

14b. To example **14a** (0.5 g, 1.2 mmol) in 10 mL of acetic acid was added 2 mL of 6N HCl/dioxane. The reaction was stirred for 20 min at ambient temperature then concentrated under vacuum. The residue was dissolved in H₂O and lyophilized yielding 0.4 g (105%) of **14b**.

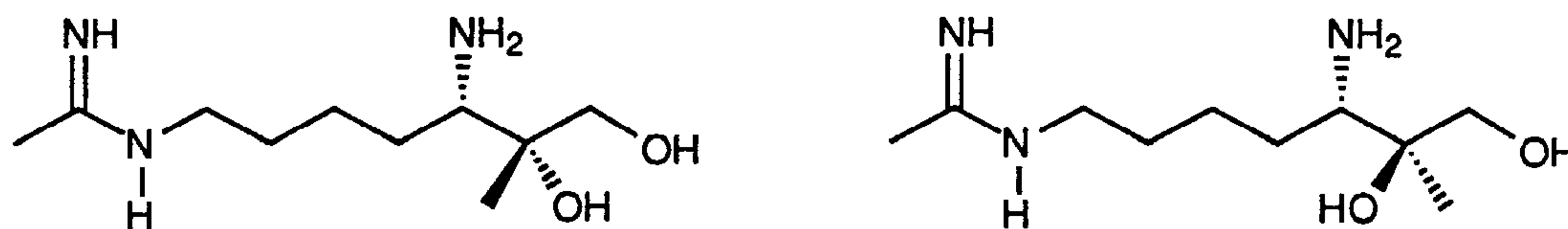
14c. To a solution of **14b** (0.4 g, 1.2 mmol) and TEA (0.56 mL, 3.9 mmol) in 10 mL of DMF was added methyl acetimidate hydrochloride (0.43 g, 3.9 mmol). After stirring for 16 h at ambient temperature, the reaction was filtered. The filtrate was concentrated under vacuum. The reaction mixture was partitioned between 15 mL 1N HCl and 20 mL DCM. The crude product from the aqueous HCl after stripping was purified using reverse phase separation, giving 0.26 g of **14c** (60.5%).

14. **14c** (0.26 g, 0.73 mmol) was reduced under catalytic hydrogenation conditions using Pd/C at 5 psi H₂ in 50% MeOH/HCl solution for 3 h. The yield of product was 0.18 g (94.7%). Analysis calcd. for C₉H₁₉N₃O·2 HCl·H₂O: C, 39.14; H, 8.39; N, 15.21. Found: C, 39.24; H, 8.32; N, 14.99.

25

Example 15

N-(5S-amino-6,7-dihydroxy-6-methylheptyl)ethanimidamide, hydrochloride dihydrate



The absolute stereochemistry of the hydroxyl group at position C-6 has not been determined. The diastereomers have been separated as described below. A difference in the biological activity between the diastereomers is seen.

15

15a. To a stirring suspension of methyltriphenylphosphonium bromide (6.21 g, 17.4 mmol) in 150 mL of toluene was added dropwise 0.5 M potassium hexamethyldisilazide in toluene (35.6 mL, 17.4 mmol). After stirring for 1.5 h, **14a** (6.85 g, 17.4 mmol) in 50 mL of toluene was added to the stirring suspension cooled to -20 °C. After 5 h, the reaction was warmed to 0 °C, washed 2x 100 mL of 1M KHSO₄, 1x 100 mL of brine, dried, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography to yield 5.3g (80%) of **15a**, a white solid.

15b. To a stirring solution of **15a** (3.3 g, 8.8 mmol) in 150 mL of acetone:H₂O (3:1) was added N-methylmorpholine N-oxide (2.05 g, 17.5 mmol) and 2.5 % OsO₄ in t-BuOH (9.5 mL, 0.9 mmol). After 18 h, 100 mL of H₂O, 25 g of celiteTM, and 6 g Na₂S₂O₄ were added to the reaction. The reaction was filtered through a pad of wet celiteTM. To the filtrate was added 180 mL of 1M KHSO₄. The filtrate was extracted with 3x 250 mL EtOAc. The combined organic layers were dried, filtered, and stripped. The residue was purified by flash chromatography to yield 3.5 g (97 %) of **15b**.

15c. To a stirring solution of **15b** (1.6 g, 3.9 mmol) in 25 mL of HOAc was added 2.5 mL of 4N HCl/dioxane. After 30 min, solvent was removed under vacuum to quantitatively recover **15c**.

15d. Example **15d** was prepared in the same manner as described in example **14c** starting with **15c** (1.36 g, 3.9 mmol). The residue was applied to a reverse phase column (YMC AQ-363-10P, ODS) using a gradient of CH₃CN/0.025 % HOAc. The first eluting isomer, **15d-1**, weighed 0.11 g; the second eluting isomer, **15d-2** weighed 0.28 g; a mixture of the two weighed 0.18 g.

15A. Example **15A** was prepared in the same manner as described for example **14** starting with **15d-1** (1.1 g, 2.6 mmol). After lyophilization, 0.82 g of **15A** was recovered. Analysis calcd. for C₁₀H₂₃N₃O₂·2 HCl·1.75 H₂O: C, 37.33; H, 8.93; N, 13.06. Found: C, 37.25; H, 8.70; N, 12.95.

15B. Example **15B** was prepared in the same manner as described for example **14** starting with **15d-2** (0.28 g, mmol). After lyophilization, 0.21 g of **15B** was recovered. Analysis calcd. for C₁₀H₂₃N₃O₂·2 HCl·2.2 H₂O: C, 36.41; H, 8.98; N, 12.74. Found: C, 36.31; H, 8.97; N, 12.34.

Example 16

N-(5S-amino-6,7-dihydroxyoctyl)ethanimidamide, dihydrochloride hydrate



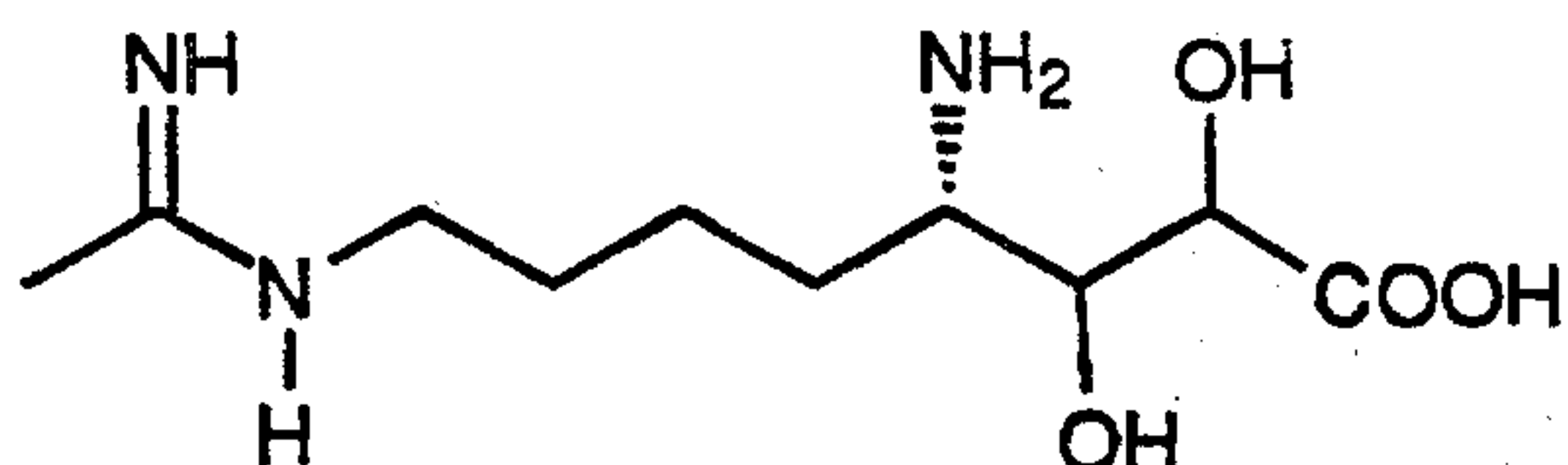
16A, 16B

16A, 16B. Example **16A** and **16B** were prepared in the same manner as described for examples **3A** and **3B** starting with **3b** and ethyltriphenylphosphonium bromide. **16B:** Analysis calcd. for C₁₀H₂₃N₃O₂·2 HCl·1.8 H₂O: C, 37.22; H, 8.93; N, 13.02. Found: C, 37.47; H, 9.05; N, 12.93.

Example 17

4S-amino-2,3-dihydroxy-8-[(1-iminoethyl)amino]octanoic acid

5



17a. Example 17a is prepared starting with 3b and (carbomethoxymethyl)triphenylphosphonium bromide.

10

17b. To a stirring solution of 17a (3.3 mmol) in 80 mL of acetone:H₂O (3:1) is added N-methylmorpholine N-oxide (0.64 g, 4.8 mmol) and 2.5 % OsO₄ in t-BuOH (3.4 mL, 0.34 mmol). After 18 h, 120 mL of H₂O, 8 g of celite™, and 1.6 g Na₂S₂O₄ are added to the reaction. The reaction is filtered through a pad of wet celite™. To the filtrate is added 200 mL of 1M KHSO₄. The filtrate is extracted with 3x 200 mL EtOAc. The combined organic layers are dried, filtered, and stripped.

15

20 17c. Benzyloxycarbonyl protecting group is removed from 17b by catalytic hydrogenation using Pd black as the catalyst yielding 17c quantitatively.

25 17d. To a stirring solution of 17c (14.9 mmol) and TEA (3.3 mL, 24 mmol) in 10 mL of DMF is added methyl acetimidate (2.44 g, 22.2 mmol). After 16 h, TEA.HCl is filtered from the reaction and is washed with a minimum of DMF. The filtrate is adjusted to pH 3 with 1N HCl. The filtrate is concentrated under high vacuum. The residue is
30 applied to a reverse phase column (YMC AQ-363-10P, ODS) using a gradient of 20 % CH₃CN/0.025 % HOAc to 50 % CH₃CN/0.025 % HOAc.

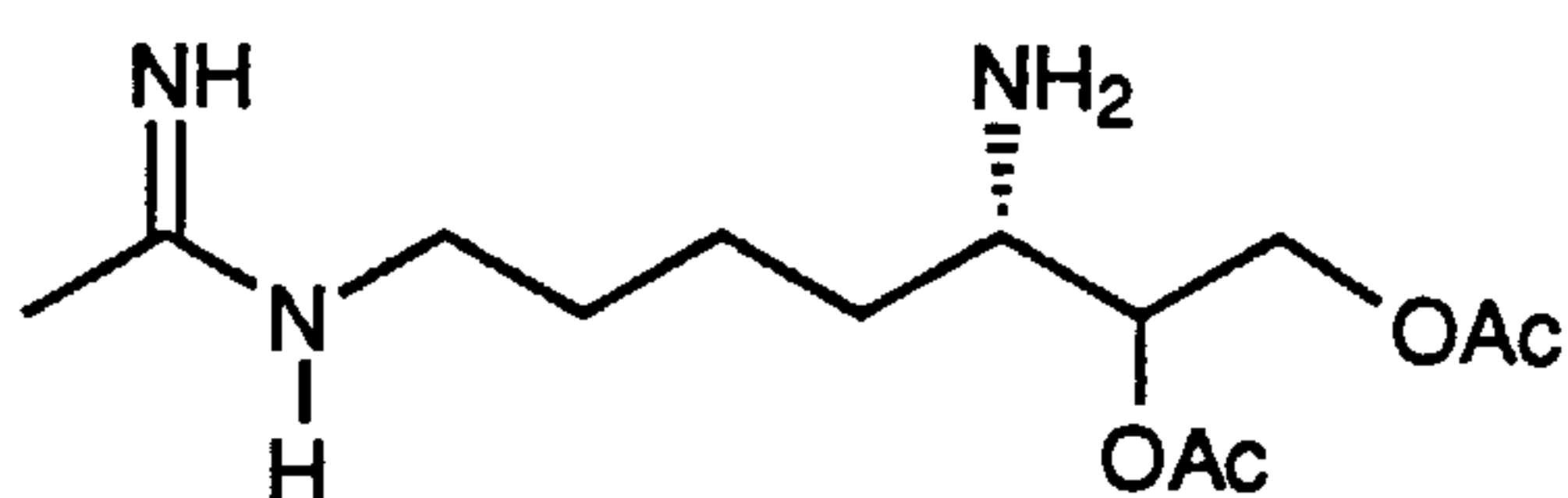
17e Example **17d** is treated with 1N HCl for 1 h at ambient temperature. The aqueous solution is lyophilized to give **17e**.

5

17. **17d** dissolved in 20 mL 2N HCl is refluxed for 60 min. The reaction is diluted with H₂O and lyophilized.

Example 18

10 **N-(6,7-diacetyloxy-5S-aminoheptyl)ethanimidamide, hydrochloride monohydrate**



15 **18a** To a stirring solution of **3e** (0.90 g, 2.3 mmol) and DMAP (0.61 g, 5.0 mmol) in DCM was added acetic anhydride (2.1mL, 23 mmol). After 18 h, solvent was removed under vacuum. The residue was taken up in 50 mL EtOAc which was washed with 3x 50 mL satd KHCO₃ solution, 1x 50 mL 1M KHSO₄,
20 and 1x 50 mL H₂O. The organic layer was dried over Na₂SO₄ anhydrous, filtered, and stripped to yield 0.99 g (89%) of **18a**, a pale yellow glass. Anal calcd for C₂₄H₃₆N₂O₈·0.2 H₂O: C, 59.54; H, 7.58; N, 5.79. Found: C, 59.75; H, 8.42; N, 6.77.

25

18b Example **18b** (0.90 g, 1.9 mmol) was prepared in same manner as **3f** to yield 0.64 g (1.8 mmol) of **18b**.

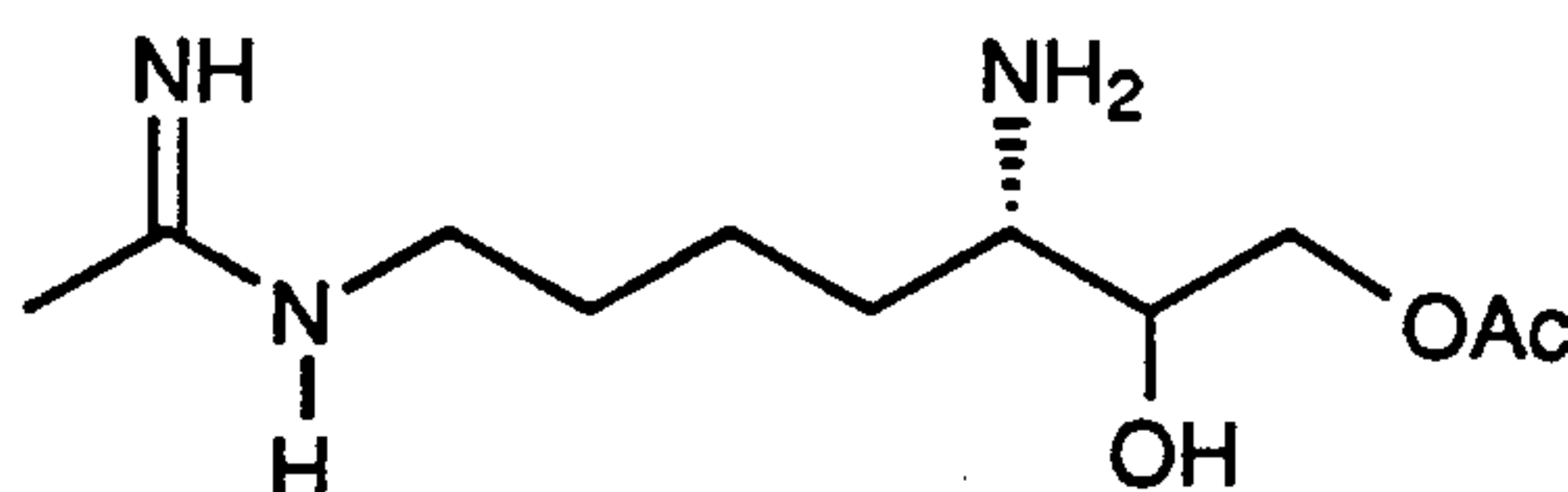
18c. To a stirring solution of **18b** (0.64 g, 1.8 mmol) in
30 10 mL of DMF was added a 2 mL solution of methyl acetimidate (0.10 g, 0.9 mmol) which had been neutralized with TEA (0.12 mL, 0.9 mmol) and filtered through glass wool to remove

TEA·HCl. This was repeated 4x over two hours. After stirring an additional 2 h, the reaction was adjusted to pH 3 with 1N HCl. After solvent was removed under vacuum, the crude product was purified by reverse phase chromatography. Not only was desired product **18c** (0.38 g, 51%) obtained but also the monoacetoxy compound, **19a** (0.11 g).

18. Example **18** was prepared from **18c** (0.38 g, 0.9 mmol) dissolved in 2 mL HOAc to which was added 1 mL 4N HCl/dioxane. The solvent was removed under vacuum. The residue was dissolved in H₂O and lyophilized to give **18** (0.26 g, 81%). Analysis calcd. for C₁₃H₂₅N₃O₄·1.75 HCl·1 H₂O: C, 42.29; H, 7.85; N, 11.38. Found: C, 42.41; H, 7.57; N, 10.68.

Example 19

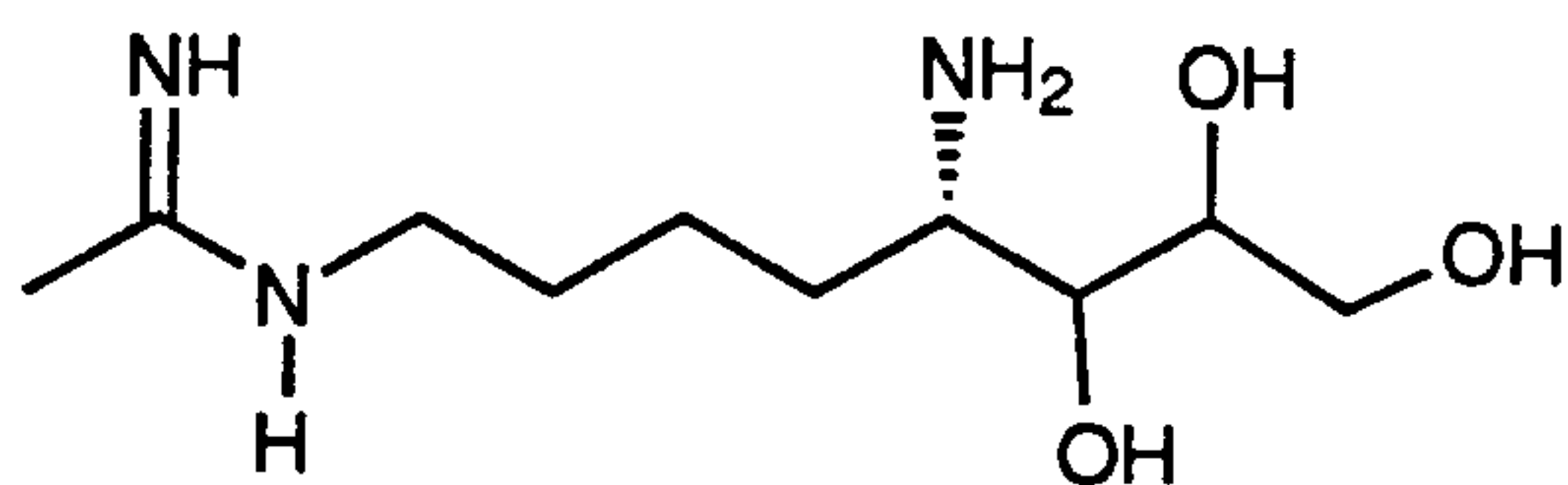
N-(5S-amino-6-hydroxy-7-acetoxyheptyl)ethanimidamide, hydrochloride monohydrate



19. Example **19a** (0.11 g, 0.29 mmol) was dissolved in 1 mL of HOAc. (see example **18c** for isolation of **19a**) To the above solution was added 1 mL of 4N HCl/dioxane. After 5 min, the solvent was removed under vacuum and the residue taken up in H₂O and lyophilized. Analysis calcd. for C₁₁H₂₃N₃O₃·2 HCl·1.2 H₂O: C, 38.87; H, 8.13; N, 12.36. Found: C, 38.81; H, 8.01; N, 12.07.

Example 20

N-(5S-amino-6,7,8-trihydroxyoctyl)ethanimidamide



20a. 17b dissolved in THF is treated with LiBH₄ to remove
5 the benzoxycarbonyl group and reduce the ester to the alcohol.

20b To a stirring solution of 20a (14.9 mmol) and TEA
(3.3 mL, 24 mmol) in 10 mL of DMF is added methyl
10 acetimidate (2.44 g, 22.2 mmol). After 16 h, TEA·HCl is
filtered from the reaction and is washed with a minimum of
DMF. The filtrate is adjusted to pH 3 with 1N HCl. The
filtrate is concentrated under high vacuum. The crude
product is purified by reverse phase chromatography

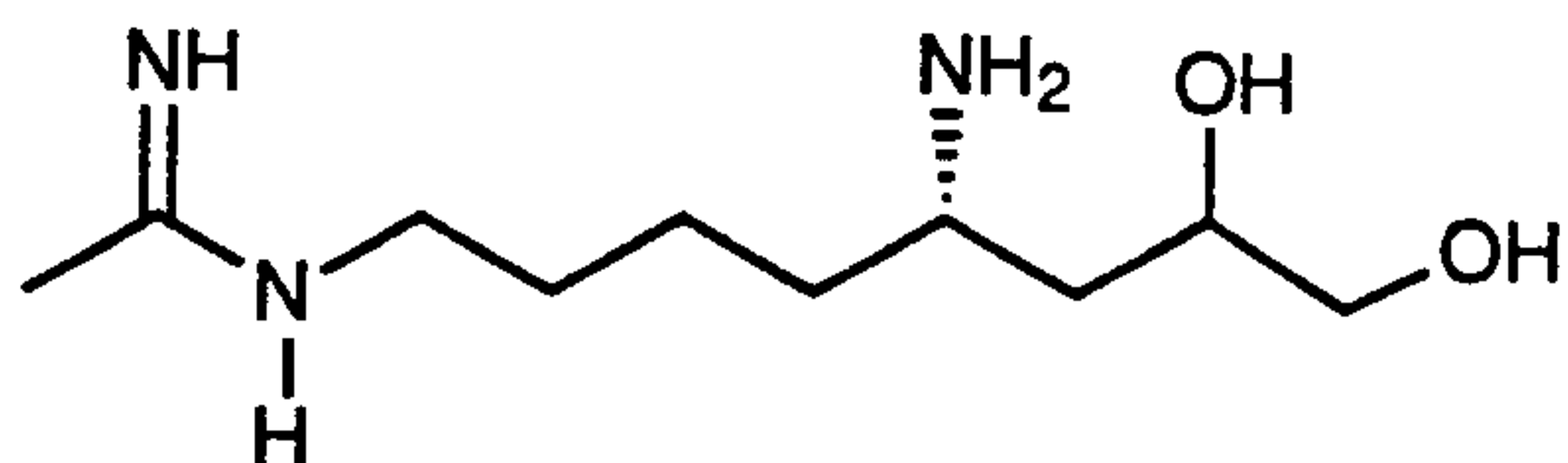
15

20 Example 20b is treated with 1N HCl for 1 h at
ambient temperature. The aqueous solution is lyophilized to
give 20.

20

Example 21

N-(5S-amino-7,8-dihydroxyoctyl)ethanimidamide



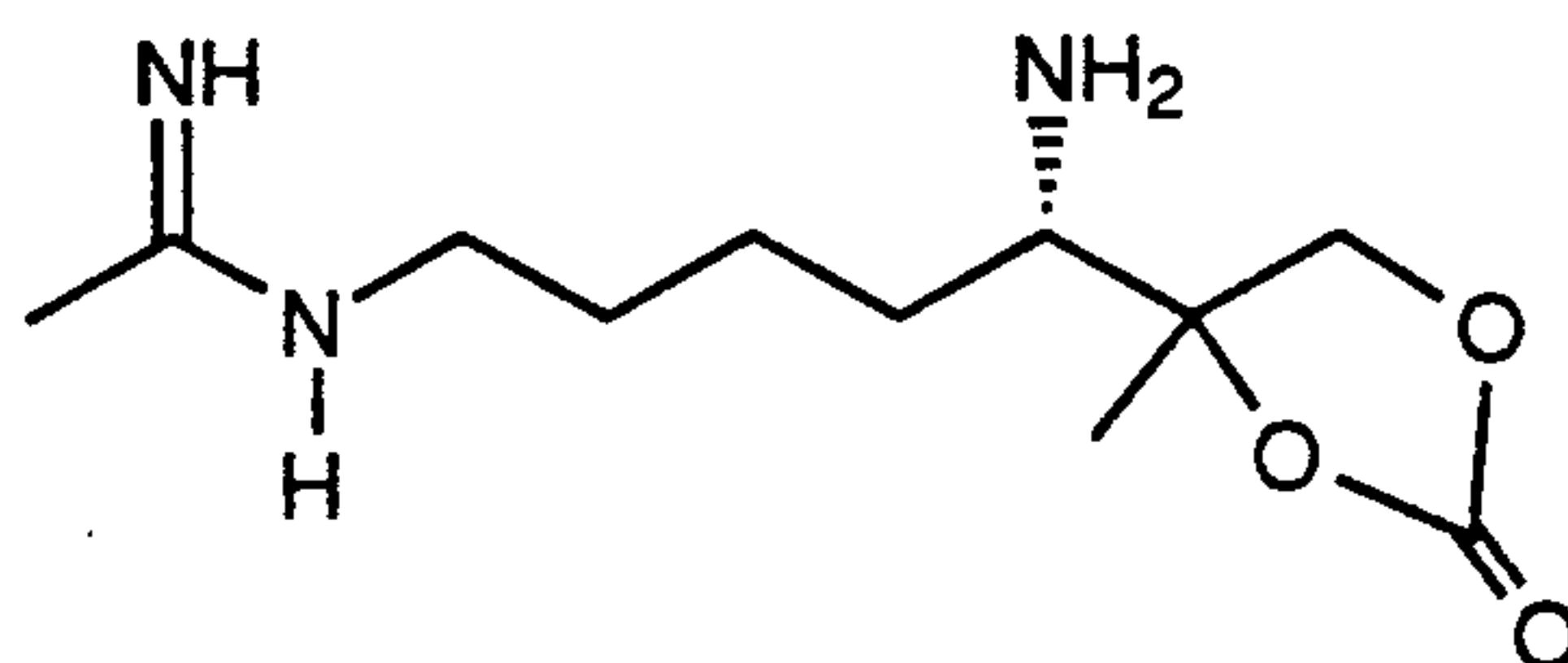
25 21. Example 21 is prepared in the same manner as 3A, 3B
starting with 1b.

Example 22

N-[5S-amino-5-(4-methyl-2-oxo-1,3-dioxolan-4-yl)pentyl]ethanimidamide

30

61

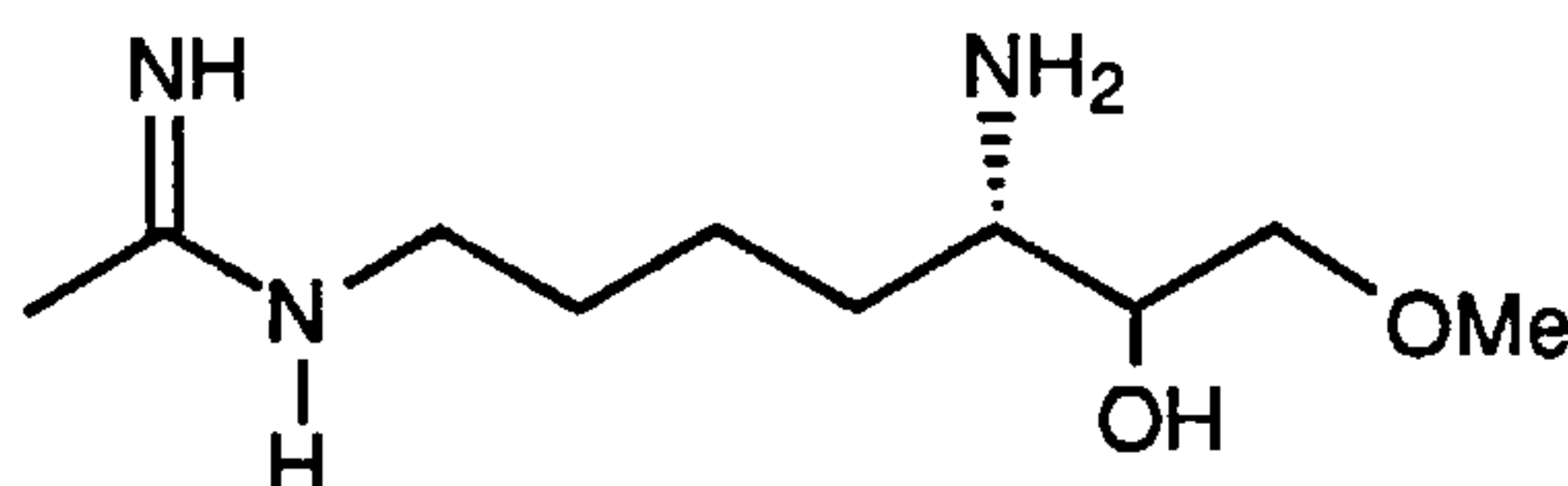


22. **15b** is treated with phosgene to generate cyclic
5 carbonate. Example 22 is synthesized by methods described
in example 15.

Example 23

N-(5S-amino-6-hydroxy-7-methoxyheptyl)ethanimidamide

10



23a. To a stirring solution of **3d** (3.62 g, 10 mmol) in
25 mL of DCM was added m-chloroperbenzoic acid (2.59 g, 15
15 mmol). After 16 h, solvent was removed under vacuum. The
resulting residue was taken up in 100 mL of EtOAc and washed
with 3x 100 mL satd KHCO₃ solution. The organic layer was
dried, filtered, and stripped. The crude product was
purified by flash column chromatography to give 2.89 g (76%)
20 of **23a**.

23b. Example **23b** is prepared in the manner described in
Tetrahedron Lett, **1994**, 35, 8977-80. To a stirring
suspension of NaOMe in 15 mL of toluene-THF (2:1) cooled to
25 -78 °C is added Et₂AlCl (3.6 mL, 3.6 mmol [1M solution]).
After 30 min, 10 mL toluene solution of **23a** (0.63 g, 1.7
mmol) is added dropwise to NaOMe suspension. The reaction
is quenched after 1.5 h with Na₂SO₄·10 H₂O (5 g) and Na₂CO₃
(0.3g). After removing the ice bath, the suspension is

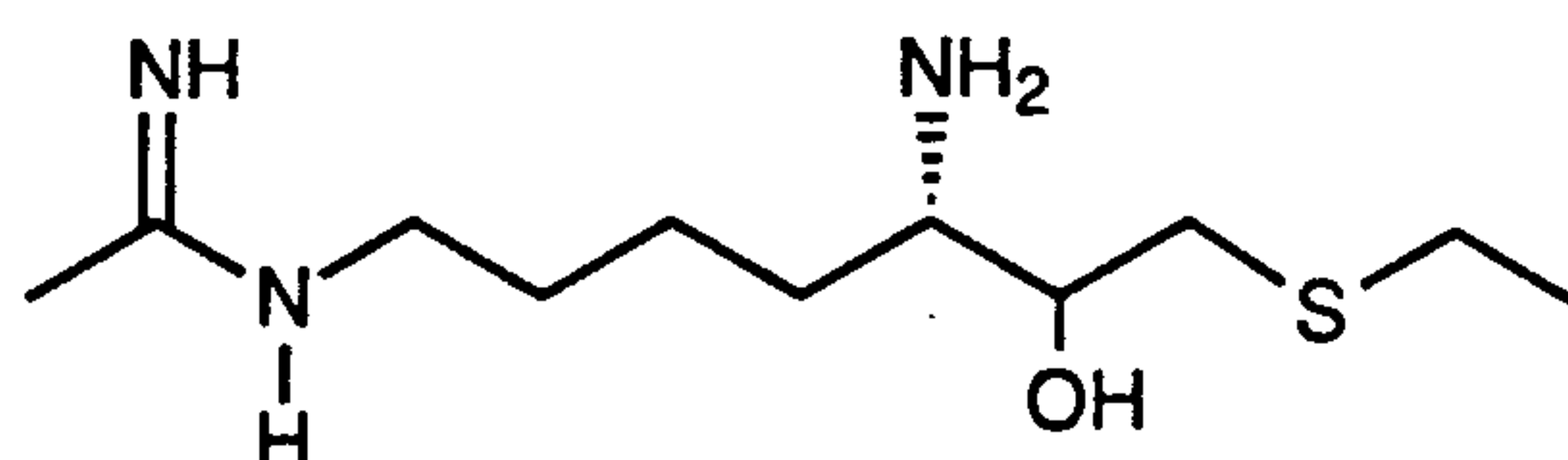
stirred for 1 h. The salts are filtered from reaction and the filtrate is concentrated to yield **23b**.

23. Example **23** is prepared from **23b** in the same manner as described in examples **3f** and **3**.

Example 24

N-[5S-amino-6-hydroxy-7-(ethylthio)heptyl]ethanimidamide

10



24a. To stirring ethanethiol (0.19 mL, 2.5 mmol) was added tetra-n-butylammonium fluoride. After 15 min, **23a** (0.79 g, 2.1 mmol) in 15 mL CH₃CN was added. After 16 h, the solvent was removed. The crude product is purified by flash chromatography.

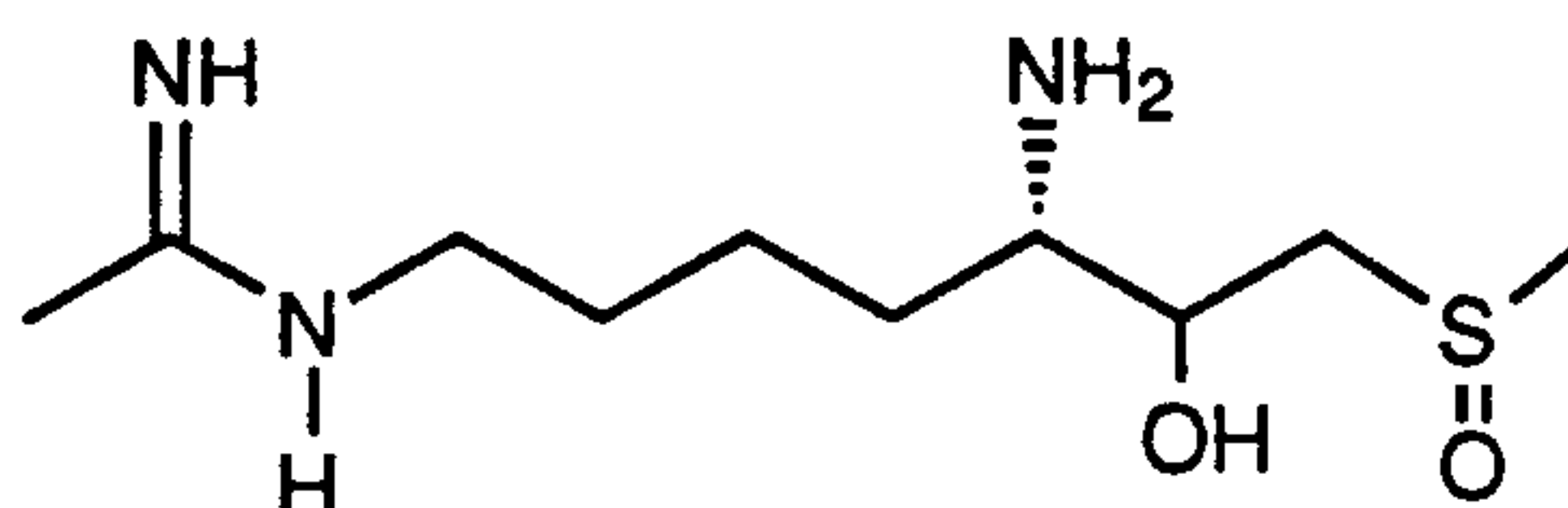
24b. Example **24a** is treated with LiAlH₄ to remove the benzyloxycarbonyl protecting group.

24. Example **24** is prepared from **24b** using conditions described in example **3**.

Example 25

N-[5S-amino-6-hydroxy-7-(methylsulfinyl)heptyl]ethanimidamide

25

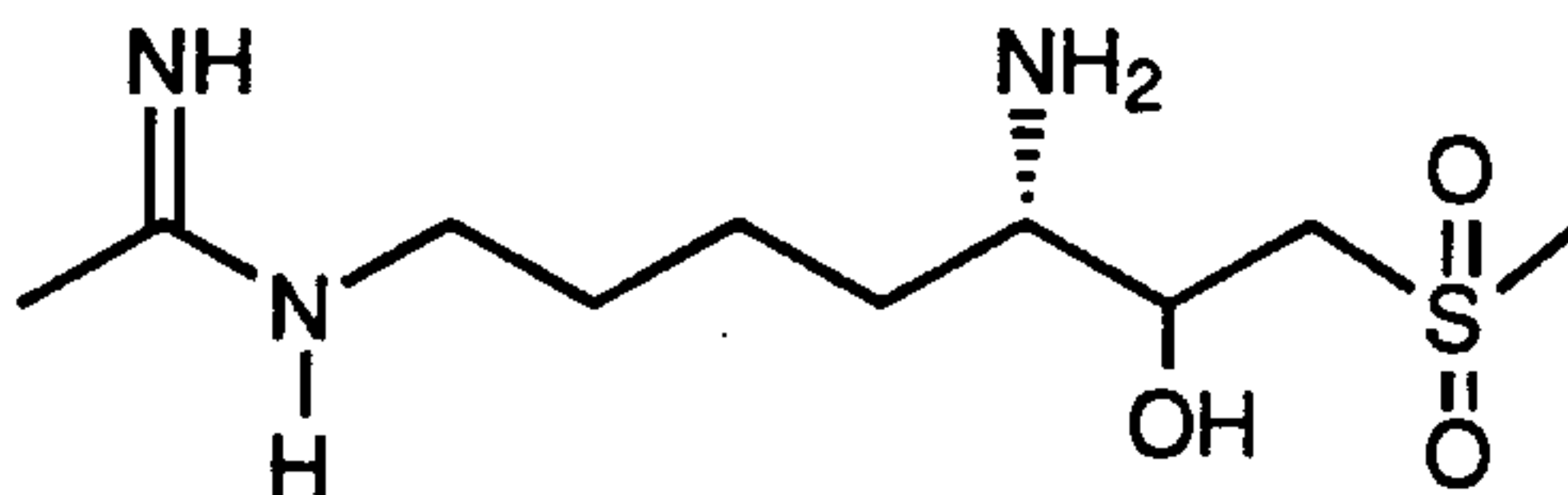


25. Example **25** is prepared from **24** by treatment with 30% H₂O₂ and acetic acid at room temperature for 1 h.

Example 26

N-[5S-amino-6-hydroxy-7-(methylsulfonyl)heptyl]ethanimidamide

5

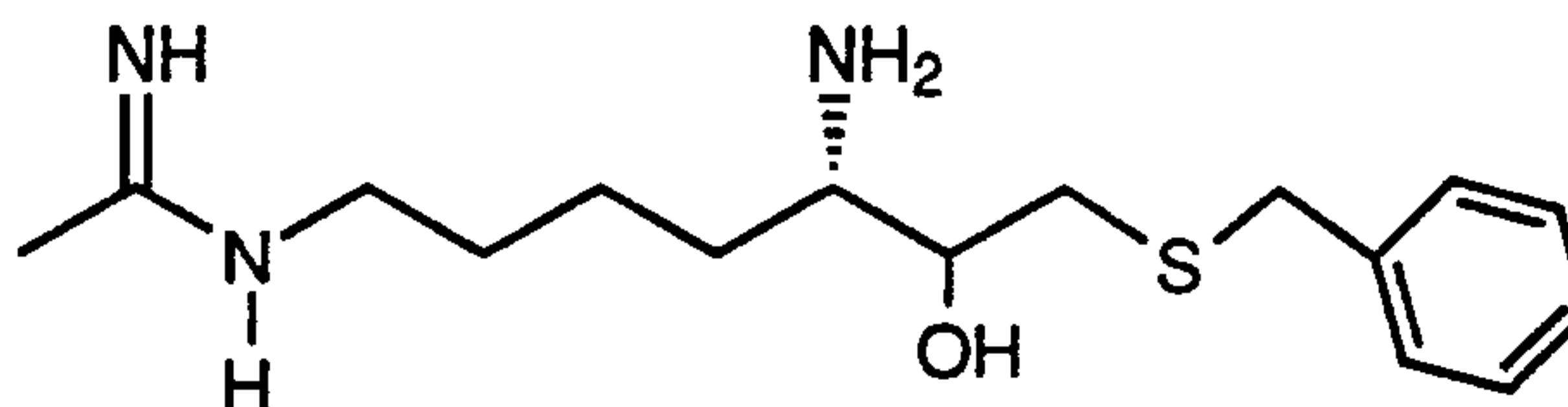


26. Example 26 is prepared from 24 by treatment with 30% H₂O₂ and acetic acid at 60 °C for 4 h.

10

Example 27

N-[5S-amino-6-hydroxy-7-[(phenylmethyl)thio]heptyl]ethanimidamide



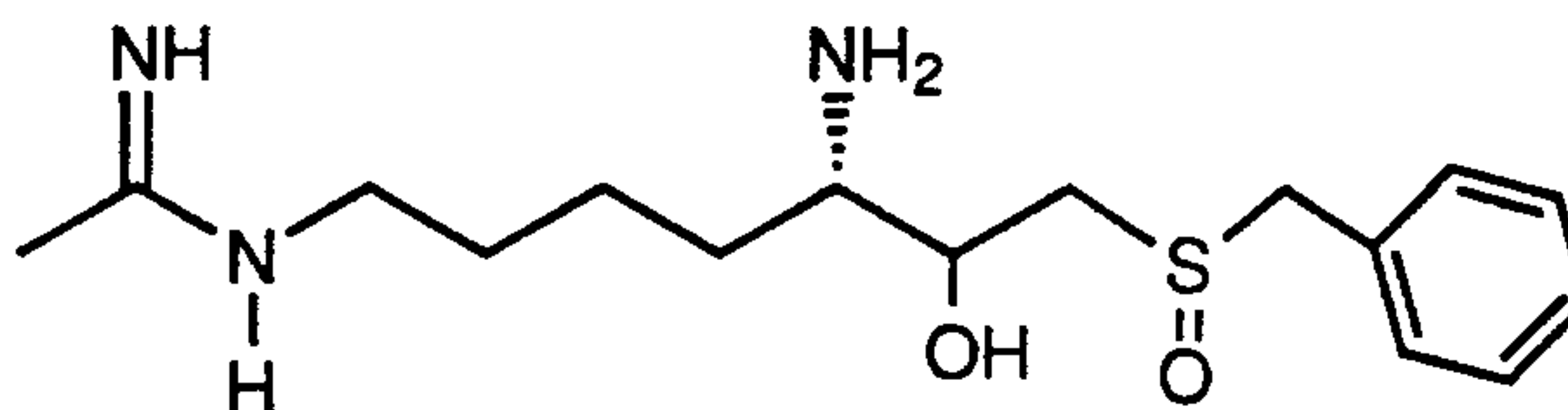
15

27. Example 27 is prepared from 23a and benzyl mercaptan in the same manner as 24.

Example 28

N-[5S-amino-6-hydroxy-7-[(phenylmethyl)sulfinyl]heptyl]ethanimidamide

20

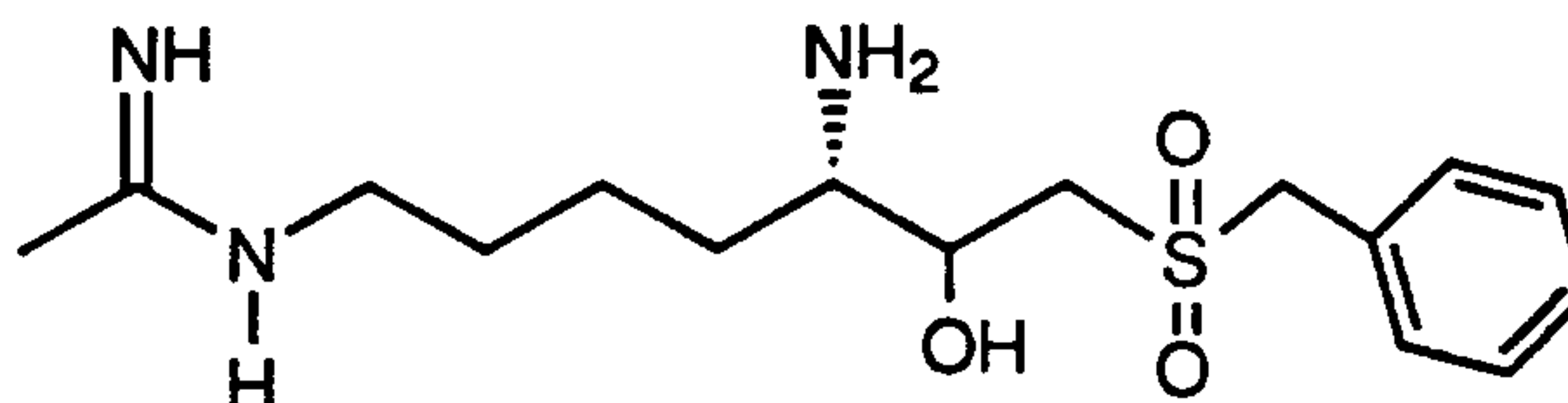


25 28. Example 28 is prepared in the same manner as 25 starting with 27.

Example 29

64

**N-[5S-amino-6-hydroxy-7-
[(phenylmethyl)sulfonyl]heptyl]ethanimidamide**



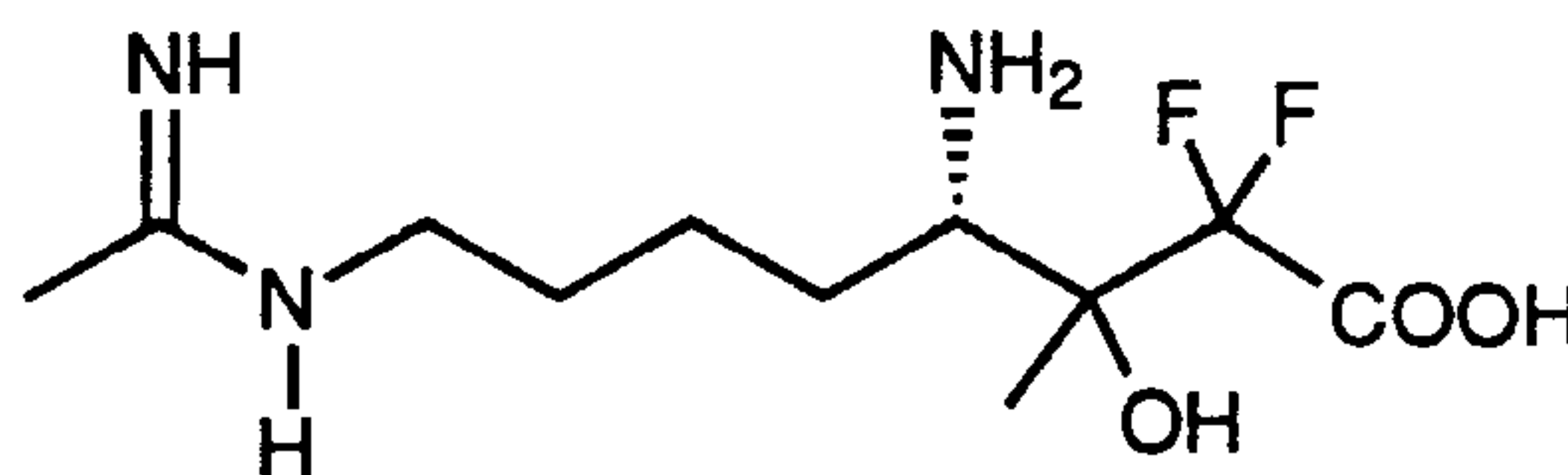
5

29. Example 29 is prepared in the same manner as 26 starting with 27.

Example 30

10

4S-amino-2,2-difluoro-3-hydroxy-8-[(1-iminoethyl)amino]-3-methyloctanoic acid



15 30a. To a refluxing suspension of Zn (2 mg-atm) and ethyl bromodifluoroacetate (2 mmol) in 10 mL is added dropwise a solution of **14a** (1 mmol) in 2 mL of THF. After 1 h, the reaction is cooled to room temperature. To the reaction is added 20 mL of EtOAc and 20 mL 1M KHSO₄. The layers are

20 separated and the organic layer is treated in the normal manner to yield **30a**.

30b. Conditions described in example 14 are used to prepare **30b** from **30a**.

30. To remove the ethyl ester from **30b**, conditions

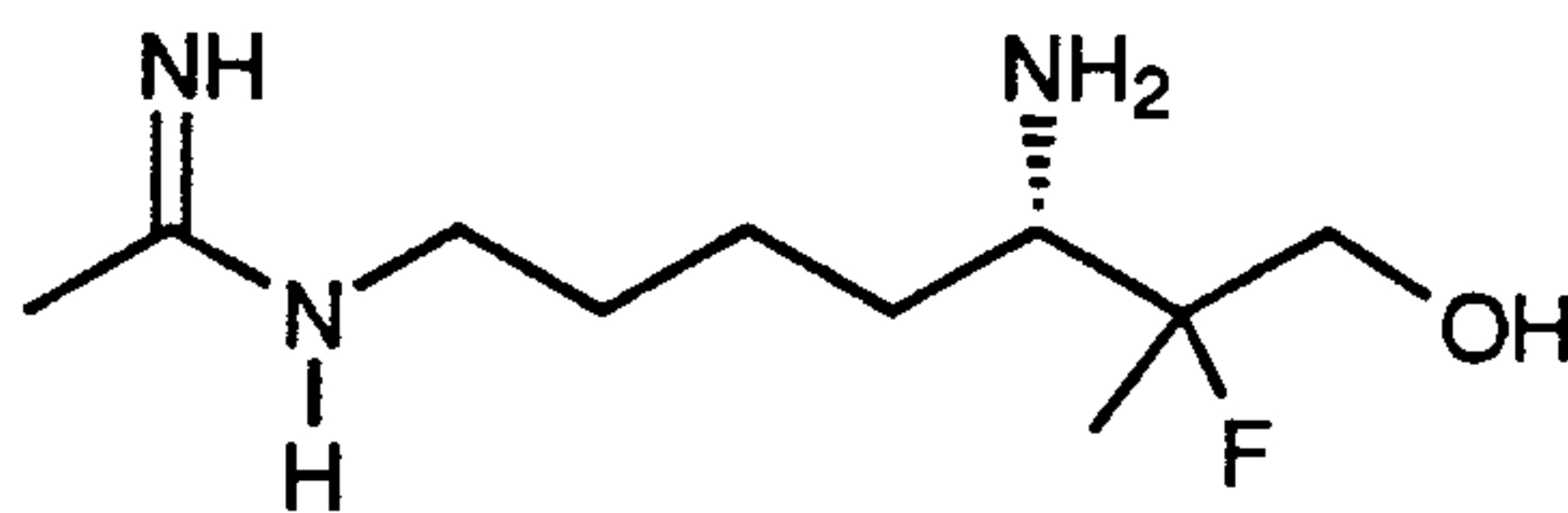
25 described in example 1 are used.

Example 31

N-(5S-amino-6-fluoro-7-hydroxy-6-methylheptyl)ethanimidamide

30

65



31a. To a stirring solution of **15b** (1.5 mmol) in 10 mL of pyridine is added Ph_3CCl (1.5 mmol). After 16 h, the reaction is concentrated under vacuum. The residue is taken up in 20 mL of EtOAc and is washed with 3x 20 mL 1M KHSO_4 , 2x 20 mL saturated KHCO_3 , and 1x 20 mL brine. The organic layer is treated in the normal manner to obtain **31a**.

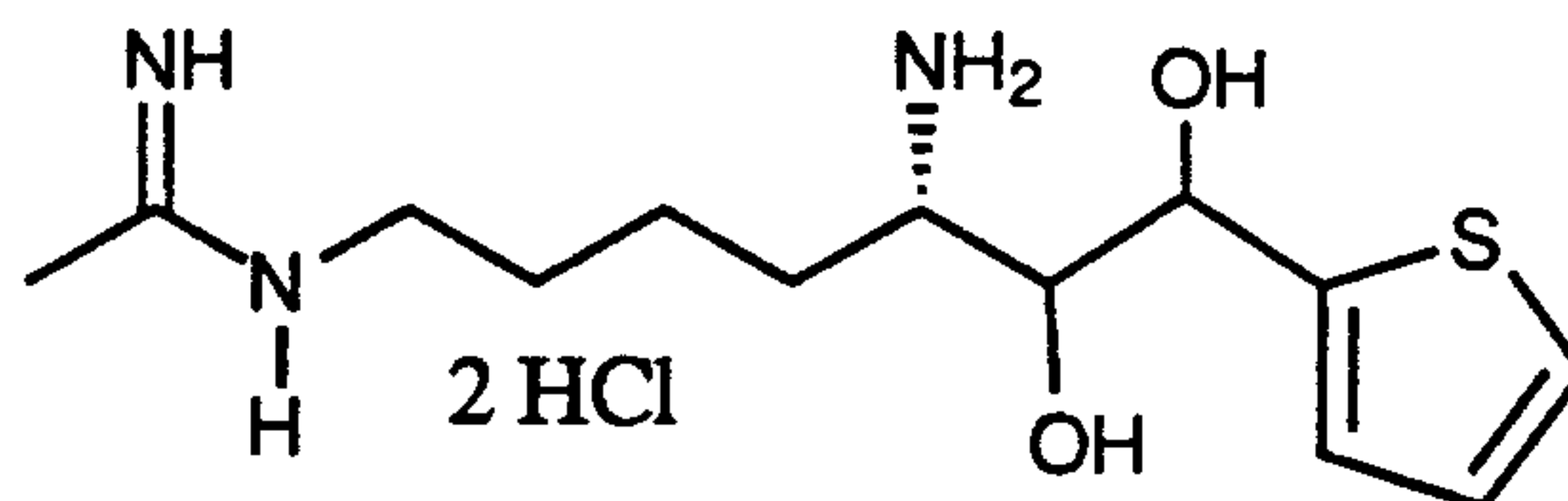
31b. To a stirring solution of **31a** in dioxane is added Et_2NSF_3 . After 40 h, the reaction is concentrated under vacuum and chromatographed to obtain **31b**.

31. Using methodology described for example 15, example 31 is synthesized from **31b**.

15

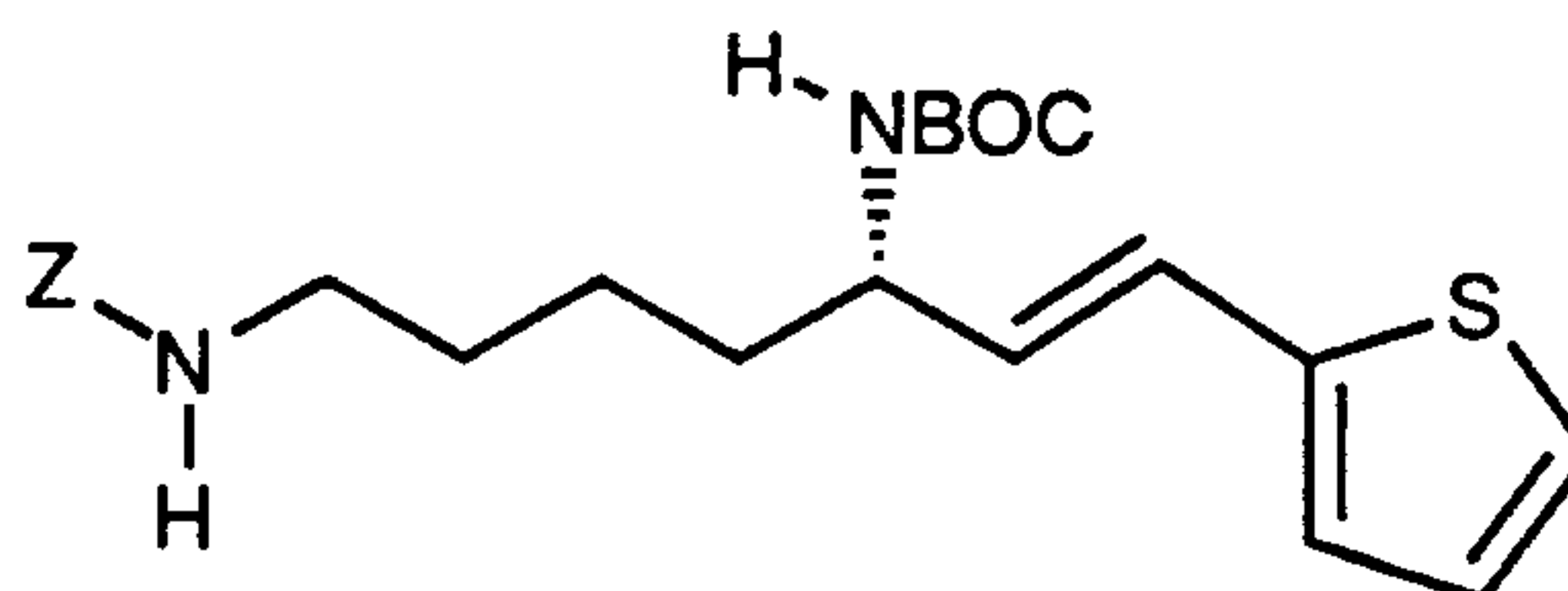
Example 32

N-[5S-amino-6,7-dihydroxy-7-(2-thienyl)heptyl]ethanimidamide, dihydrochloride



20

32

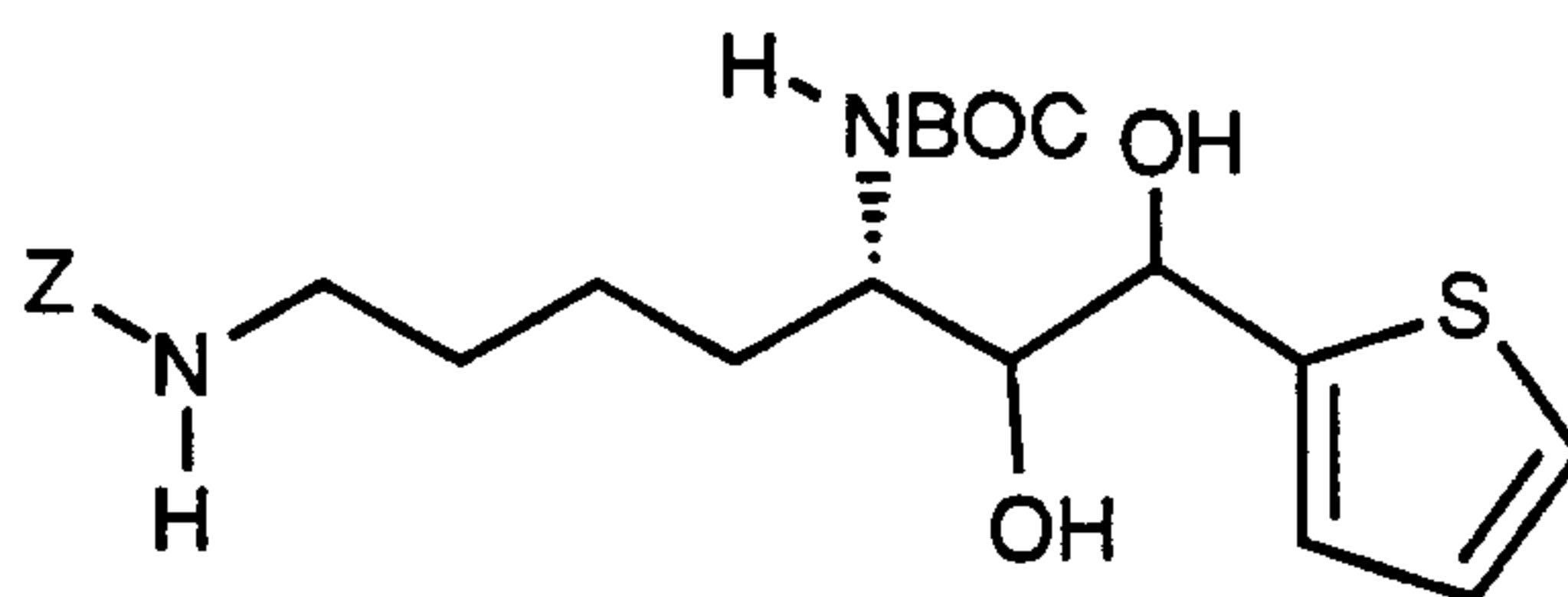


32a

25

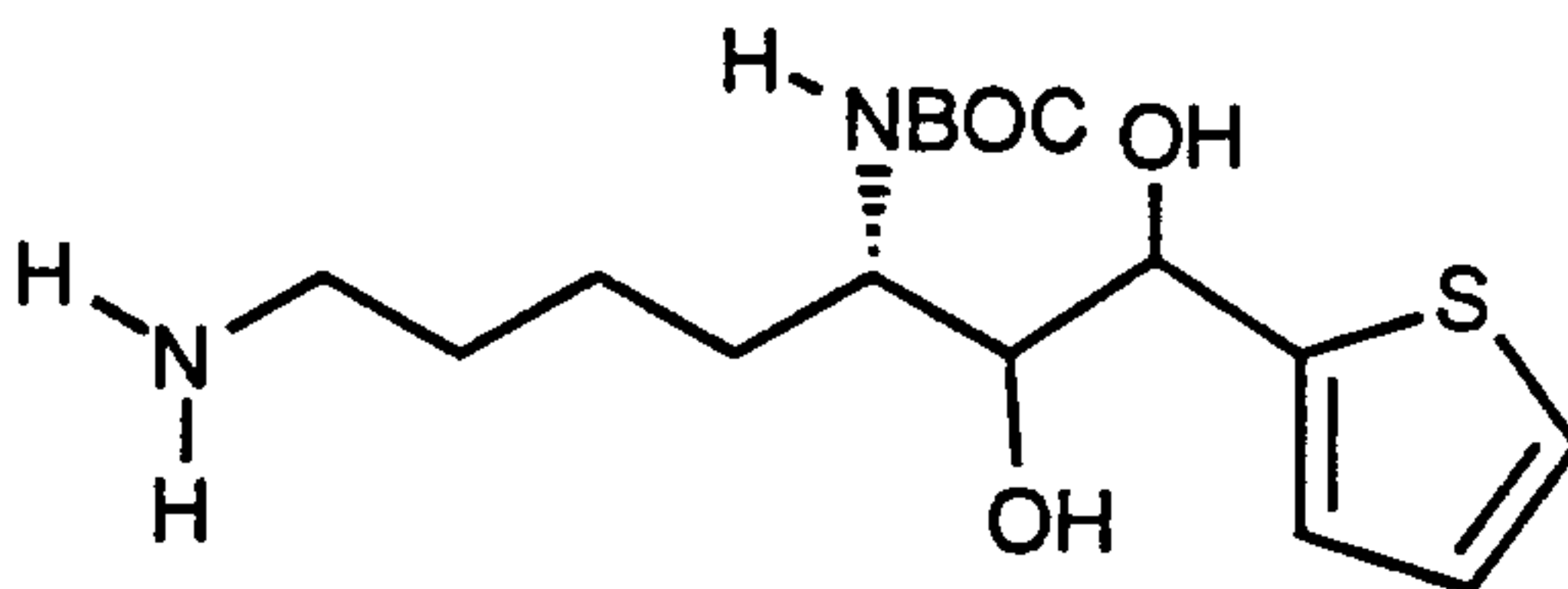
66

32. A mixture of palladium acetate (Johnson Matthey, 0.29 mmol), tri-*o*-tolylphosphine (0.6 mmol), 2-bromothiophene (16.0 mmol), and triethylamine (16 mmol) is refluxed under nitrogen for 30 min. The mixture is cooled to room temperature, and **3d** (14.4 mmol) in 6 mL of acetonitrile is added. The reaction is refluxed for 24 h, cooled to room temperature, and stripped of all solvent under reduced pressure. The residue is partitioned between sat. NaHCO₃ and EtOAc and the organic phase is dried (MgSO₄), filtered, and stripped. The residue is chromatographed on silica gel to give **32a**.

**32b**

15

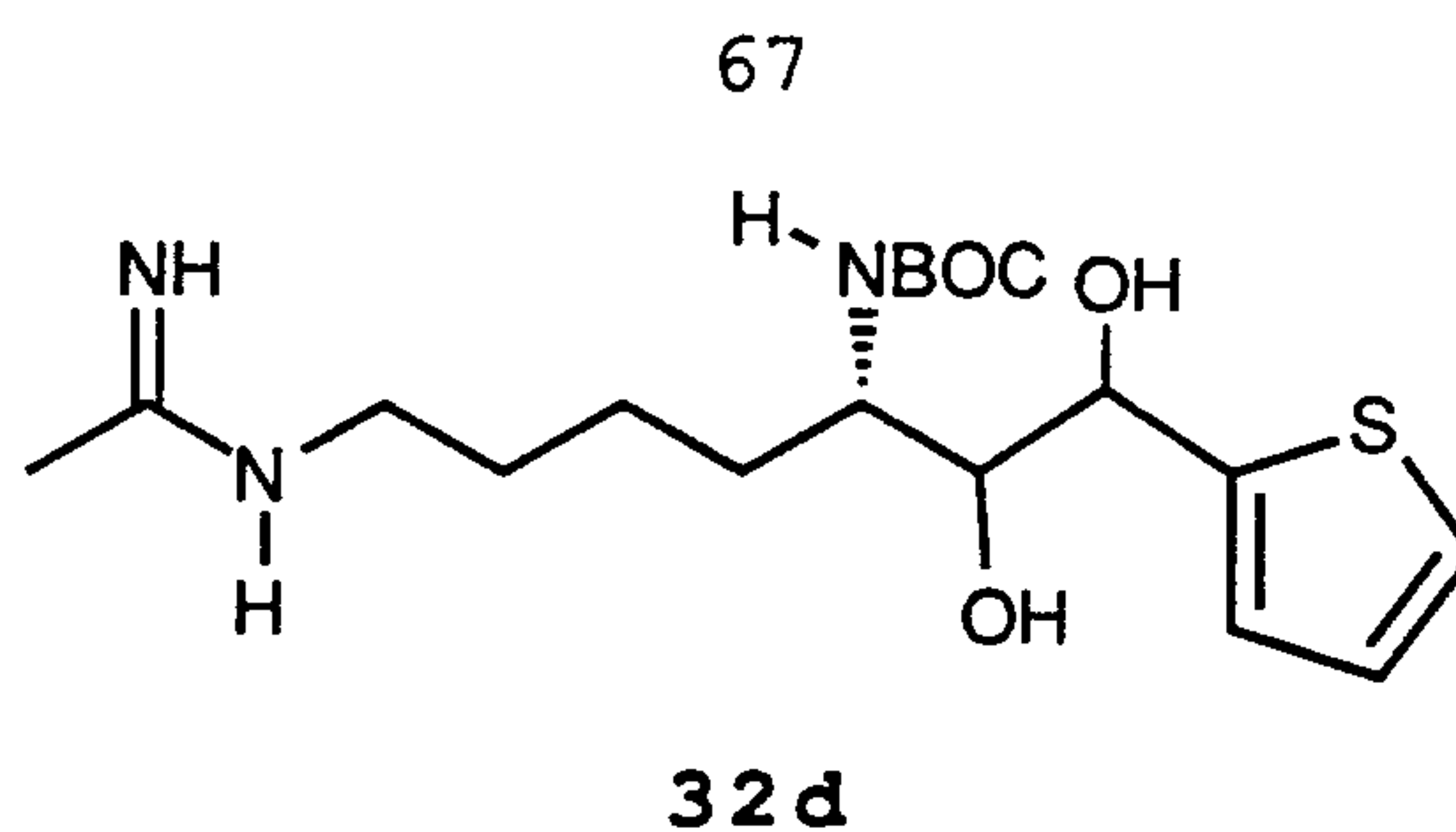
32b. Osmium tetroxide is reacted with **32a** by the method used in the preparation of **3e**, to yield **32b**.

**32c**

20

32c. A solution of **32b** in AcOH is treated with H₂ (5 psi) over Pd black for 20 h. The reaction mixture is assessed by thin layer chromatography to find the extent of reaction. If necessary, fresh Pd black is added and the reaction continued. This process is repeated until the reaction is completed. The reaction mixture is filtered and concentrated *in vacuo* to yield **32c**.

25

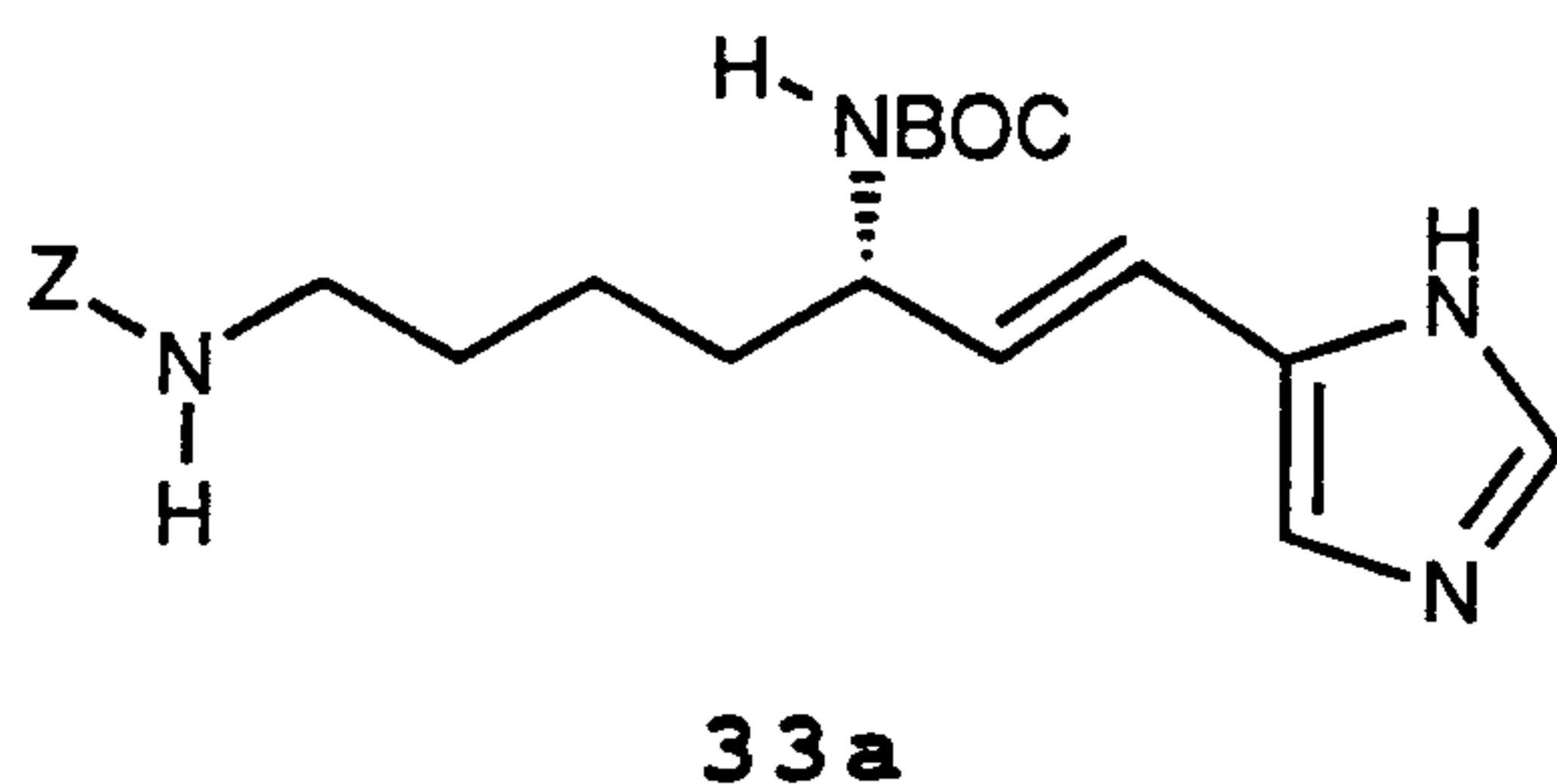
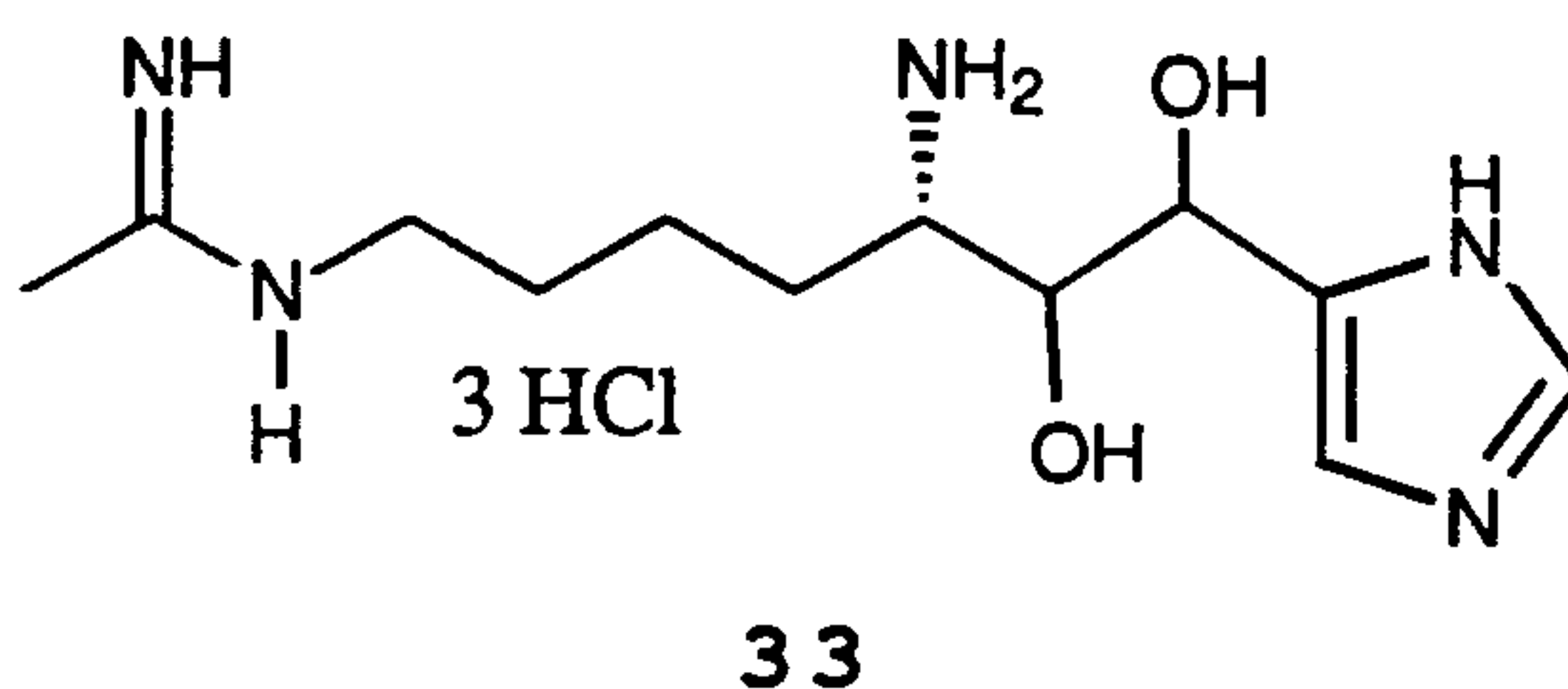


- 32d.** An equimolar solution of **32c** and ethyl acetimidate hydrochloride in EtOH is stirred for 18 h. The reaction solution is concentrated *in vacuo* to yield a white foam. This material is purified by reversed phase HPLC to yield **32d**.
- 32.** To a stirred solution of **32d** in AcOH (glacial) is added HCl (6.95 M in dioxane). The resulting solution is stirred for 2 h. The solution is concentrated *in vacuo* and triturated with diethyl ether to yield **32**.

15

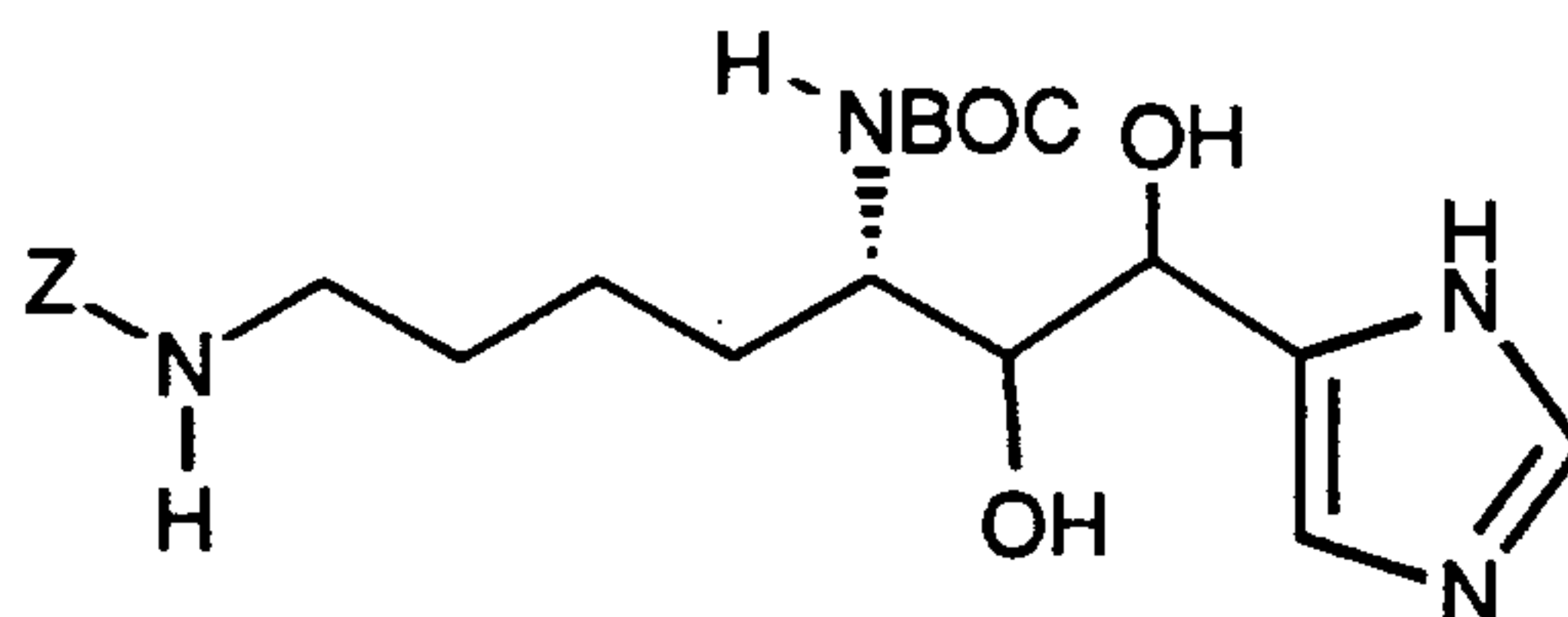
Example 33

N-[5S-amino-6,7-dihydroxy-7-(1H-imidazol-5-yl)heptyl]ethanimidamide, trihydrochloride



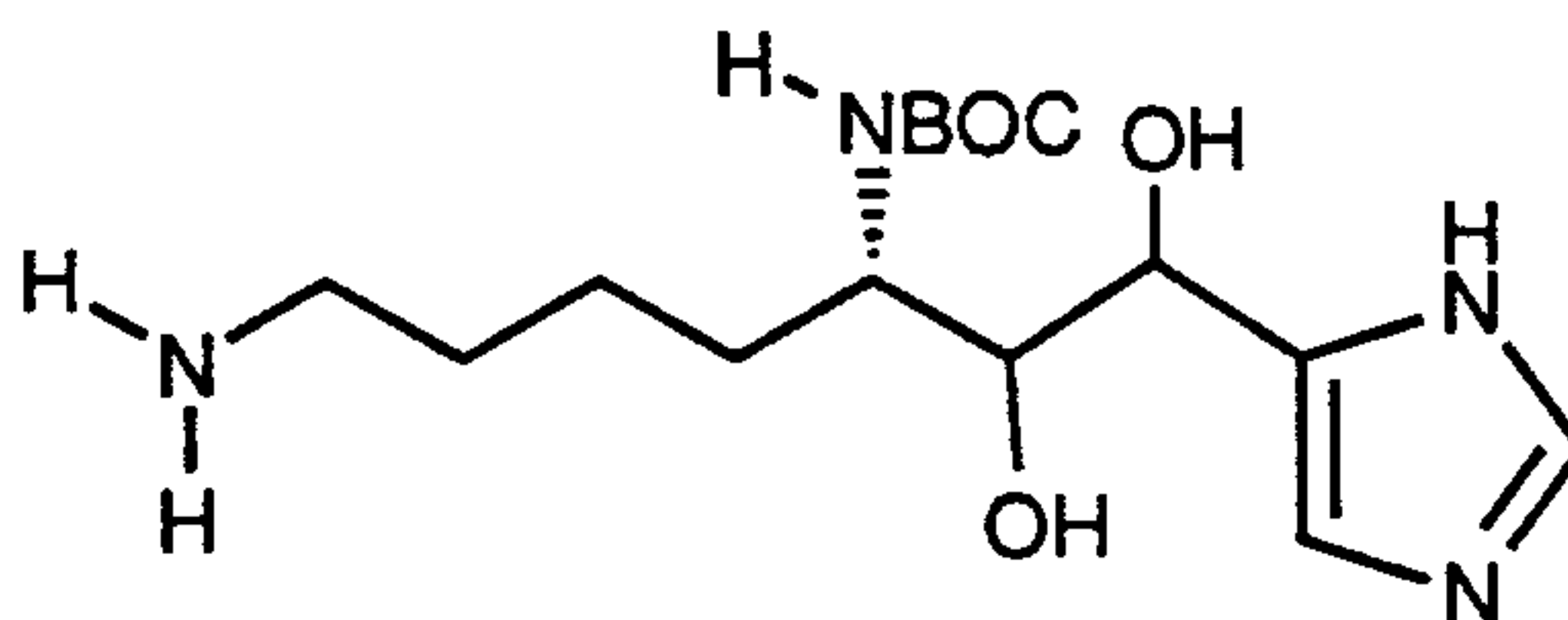
33a. 4-Bromoimidazole (K&K Laboratories) is treated as described in the preparation of **32a**, replacing the 2-bromothiophene in that preparation. The product is **33a**.

5

**33b**

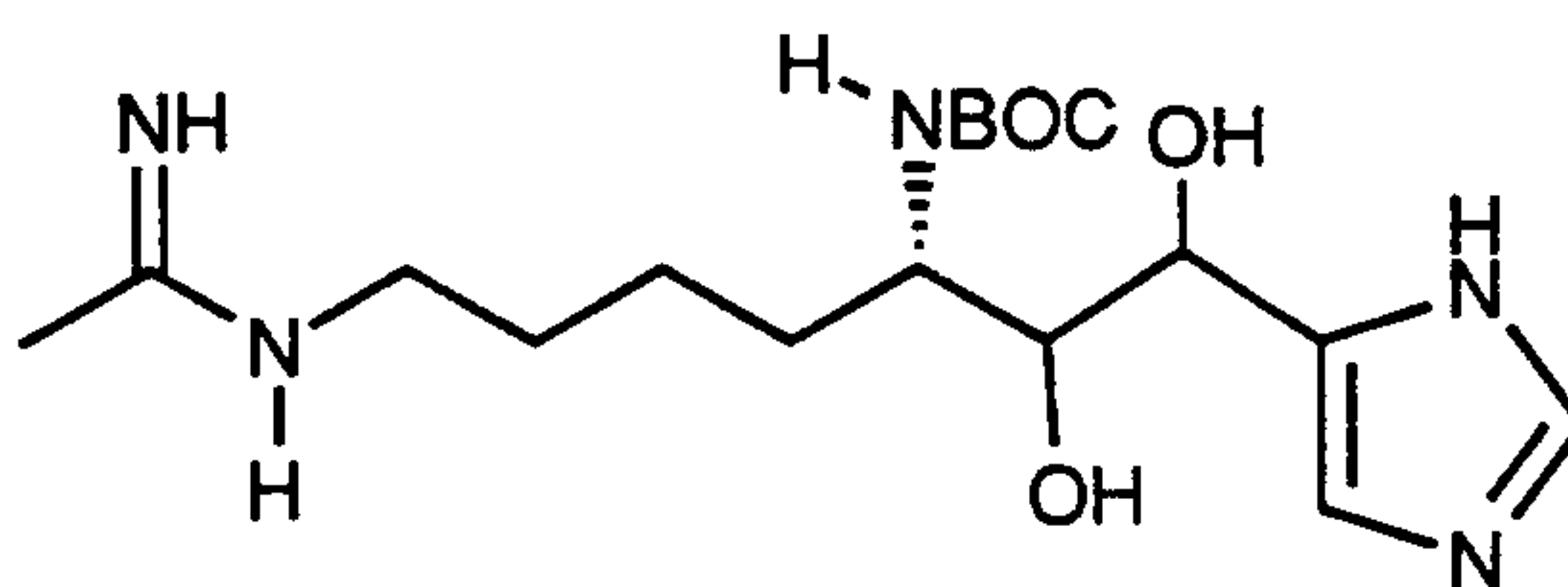
33b. By the method of Example **3e**, osmium tetroxide is reacted with **33a** to yield **33b**.

10

**33c**

33c. A solution of **33b** in AcOH is treated with H₂ (5 psi) over Pd black for 20 h. The reaction mixture is filtered and concentrated in vacuo to yield **33c**.

15

**33d**

20

33d. An equimolar solution of **33c** and ethyl acetimidate hydrochloride in EtOH is stirred for 18 h. The reaction solution is concentrated in vacuo to yield a

69

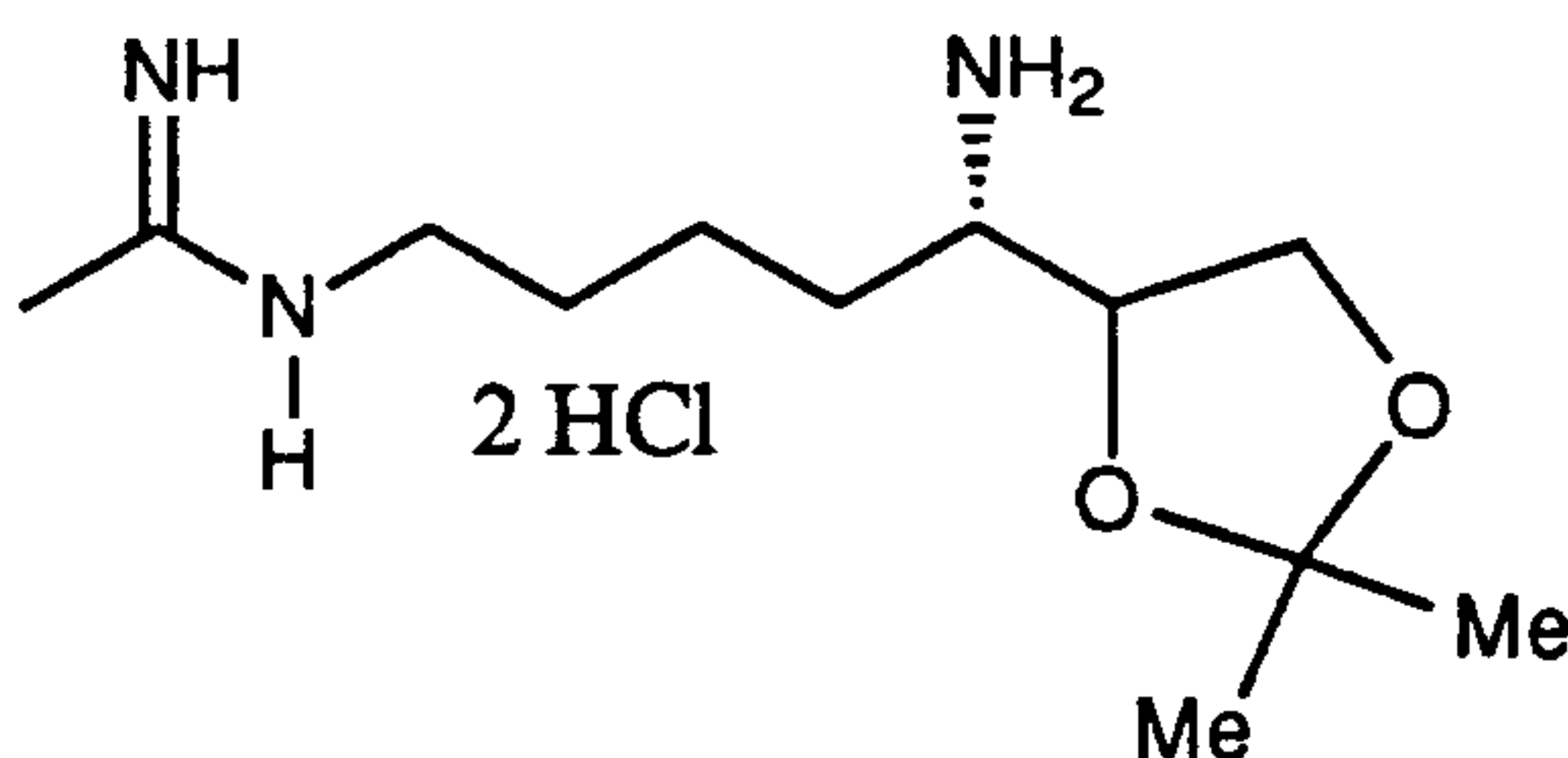
white foam. This material is purified by reversed phase HPLC to yield **33d**.

33. To a stirred solution of **33d** in AcOH (glacial) is added HCl (6.95 M in dioxane). The resulting solution is stirred for 2 h. The solution is concentrated *in vacuo* and triturated with diethyl ether to yield **33**.

10

Example 34

N-[5S-amino-5-(2,2-dimethyl-1,3-dioxolan-4-yl)pentyl]ethanimidamide, dihydrochloride



15

34

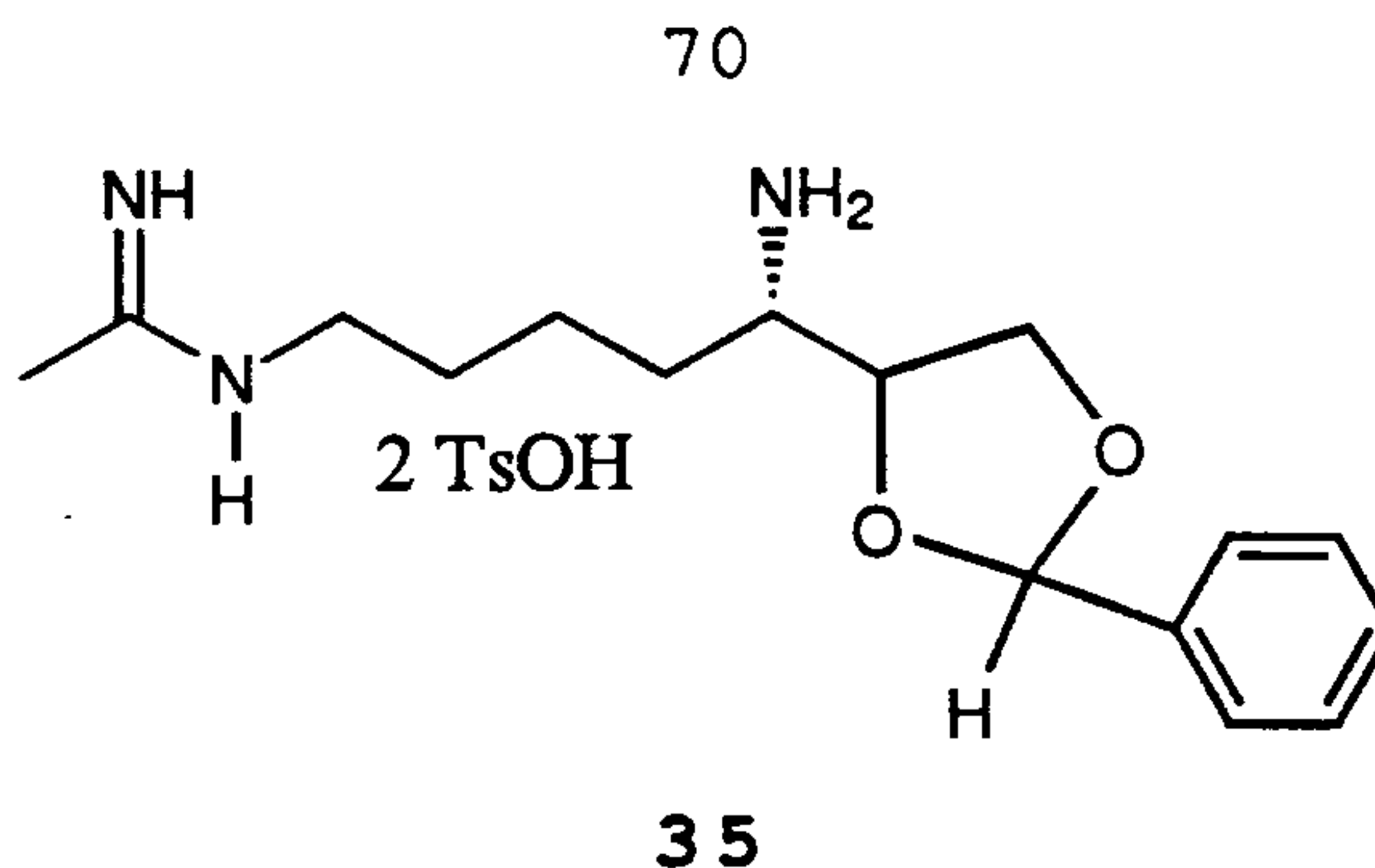
34. **3B** (10 mmol) is dissolved in DMF and 2,2-dimethoxypropane (20 mmol) is added, as is 6N HCl in dioxane (2 mmol). The mixture is protected from moisture and stirred overnight. It is then stripped to a residue in a rotary evaporator using an oil pump as a vacuum source. The residue is suspended in dry acetone, stirred for 30 min, and stripped again. The resulting residue is dissolved in cold water, shelled, and lyophilized to give **34**.

25

Example 35

N-[5S-amino-5-(2-phenyl-1,3-dioxolan-4-yl)pentyl]ethanimidamide, di(4-methylbenzenesulfonate)

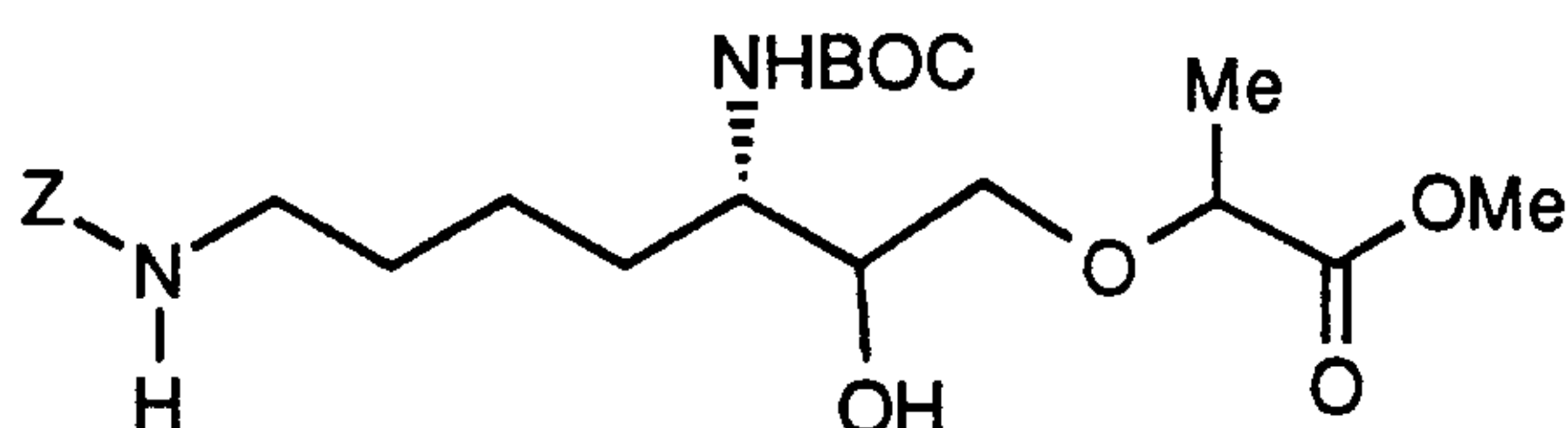
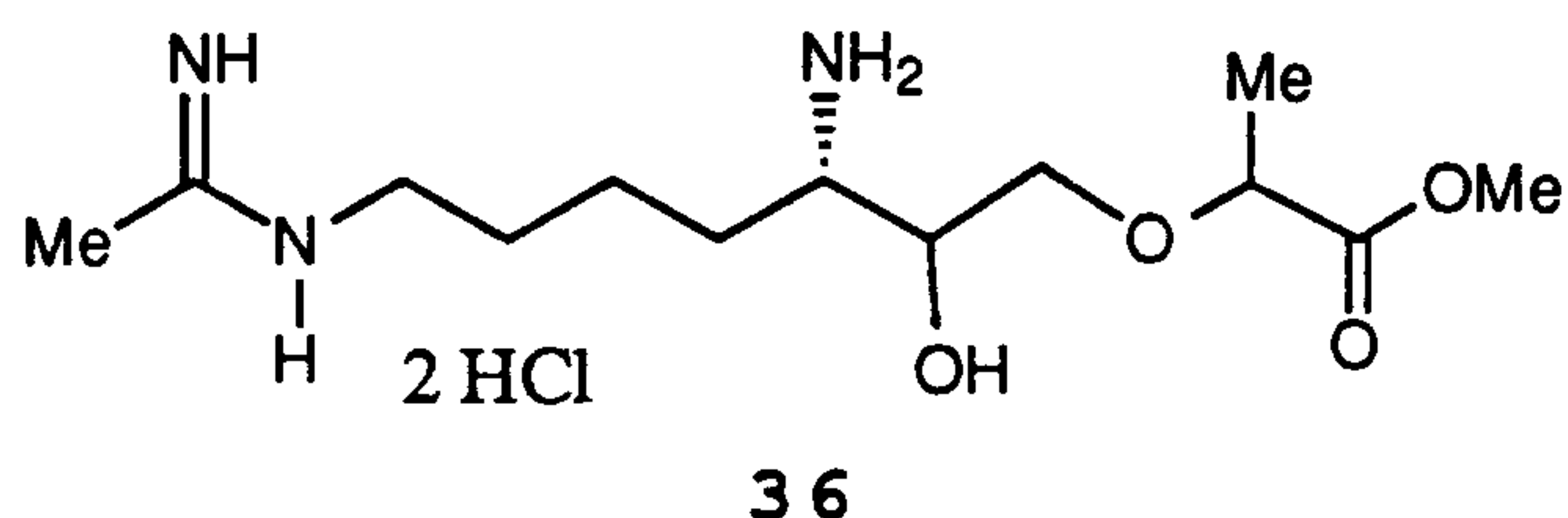
30



35. **3B** (27.7 mmol), 1,1,1-trichloroethane (350 mL),
 5 benzaldehyde (55.4 mmol), and toluensulfonic acid
 monohydrate (55.4 mmol) are placed in a 500 mL round bottom
 single neck flask fitted with a Soxhlet extractor whose
 thimble is filled with 5A molecular sieves (8-12 mesh
 beads). The flask is immersed in an oil bath (bath
 10 temperature 120 °C) and the mixture is refluxed with
 vigorous stirring for 16 h. The reaction is then cooled and
 the mixture is stripped to a residue in a rotary evaporator
 using an oil pump as a vacuum source. The residue is
 dissolved in cold water, shelled, and lyophilized to give
 15 **35**.

Example 36

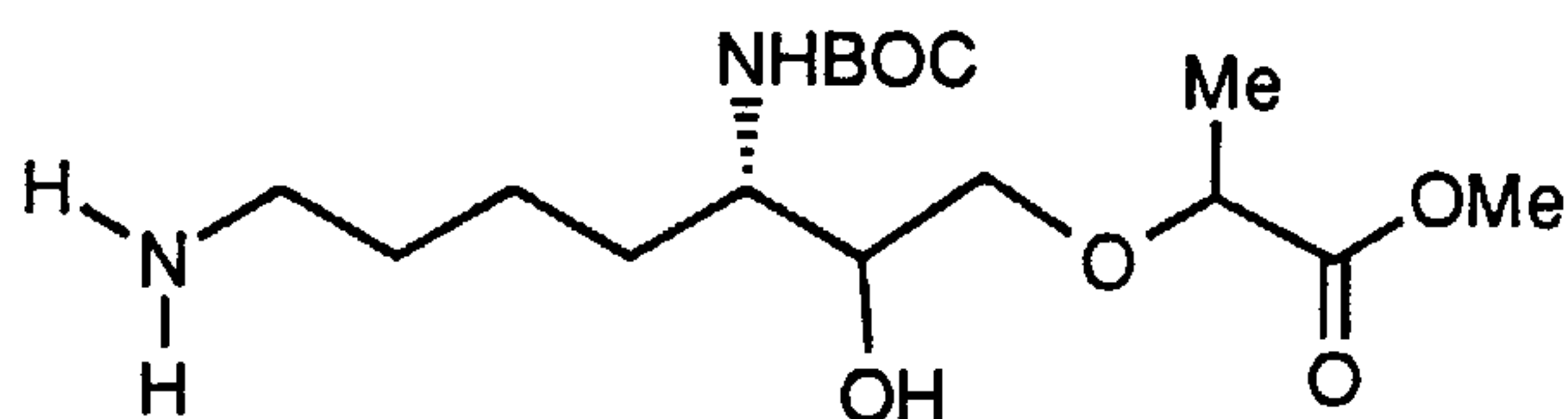
**methyl 2-[[[3S-amino-2-hydroxy-7-[(1-
 iminoethyl)amino]heptyl]oxy]propanoate,
 20 dihydrochloride**



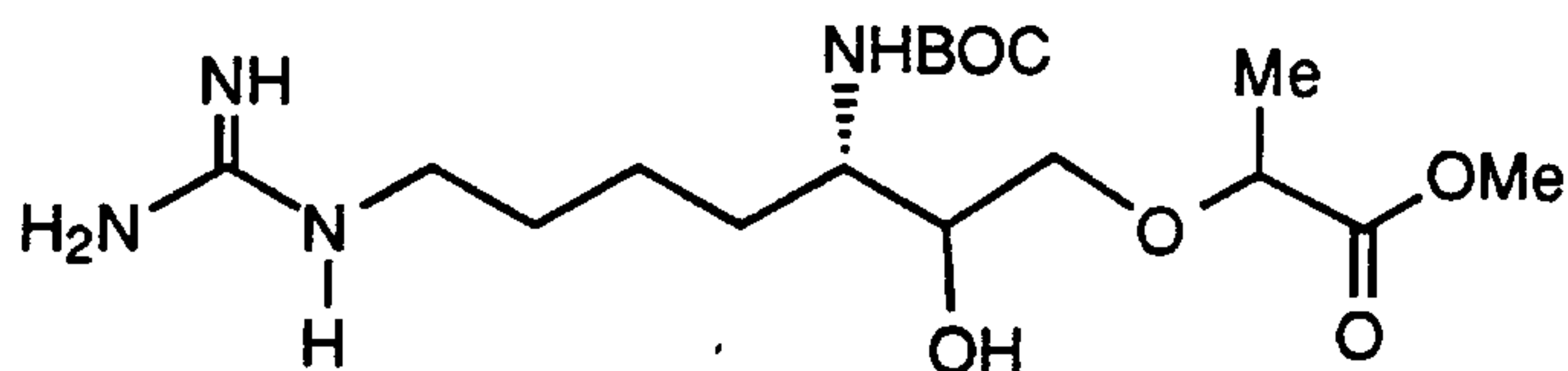
71

36a

36a. Sodium hydride (50% in mineral oil, 10.5 mmol) is washed twice with hexane and suspended in DMF. Methyl lactate (10 mmol) is dissolved in DMF and added carefully to the NaH suspension with stirring. The mixture is stirred for 30 min, and a solution of **23a** (9 mmol) and anhydrous zinc chloride (9 mmol) in THF is added. This mixture is immersed in a 60 °C oil bath and stirred overnight. It is then worked up to give **36a**.

**36b**

36b. A solution of **36a** in AcOH is treated with H₂ (5 psi) over Pd black for 20 h. The reaction mixture is filtered and concentrated *in vacuo* to yield **36b**.

**36c**

36c. An equimolar solution of **36b** and ethyl acetimidate hydrochloride in EtOH is stirred for 18 h. The reaction solution is concentrated *in vacuo* to yield a white foam. This material is purified by reversed phase HPLC to yield **36c**.

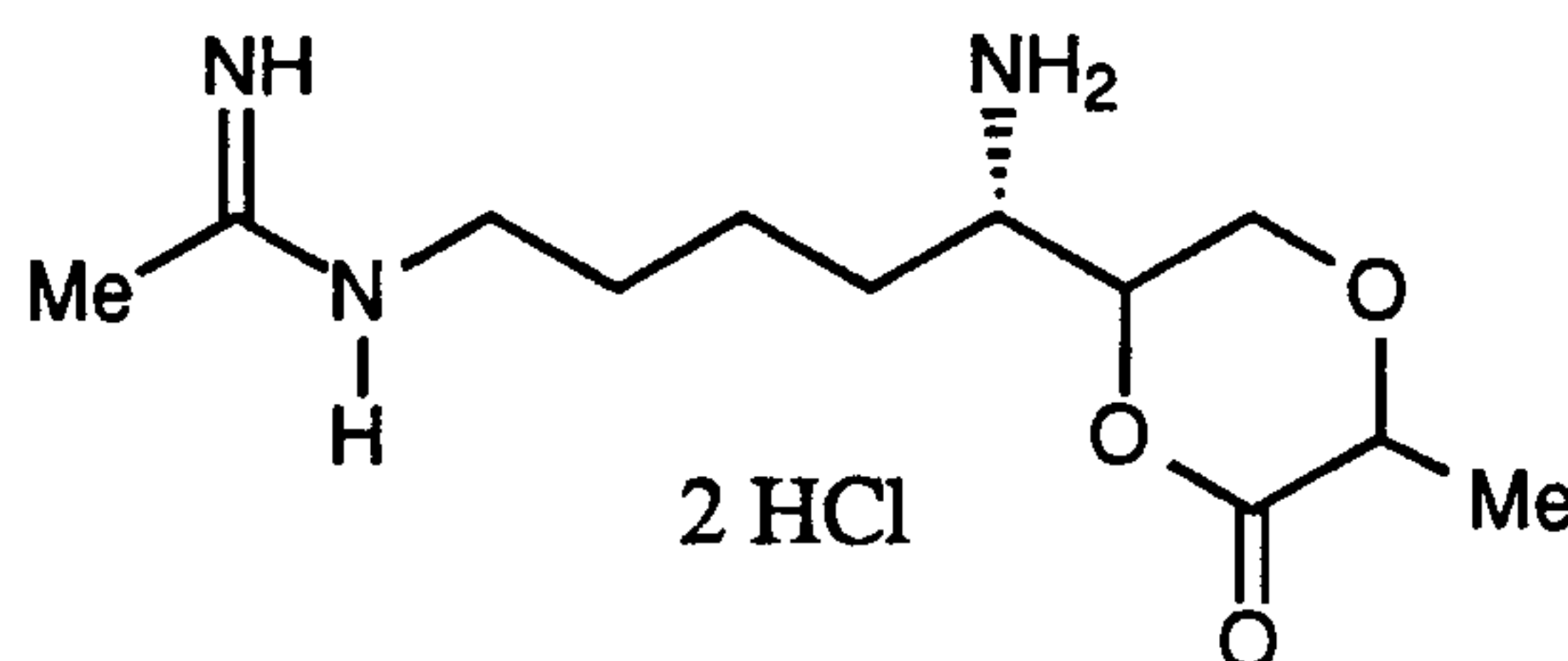
36. To a stirred solution of **36c** in AcOH (glacial) is added HCl (6.95 M in dioxane). The resulting solution is

72

stirred for 2 h. The solution is concentrated *in vacuo* and triturated with diethyl ether to yield **36**.

Example 37

5 **N-[5S-amino-5-(2-methyl-3-oxo-1,4-dioxan-5-yl)pentyl]ethanimidamide, dihydrochloride**

**37**

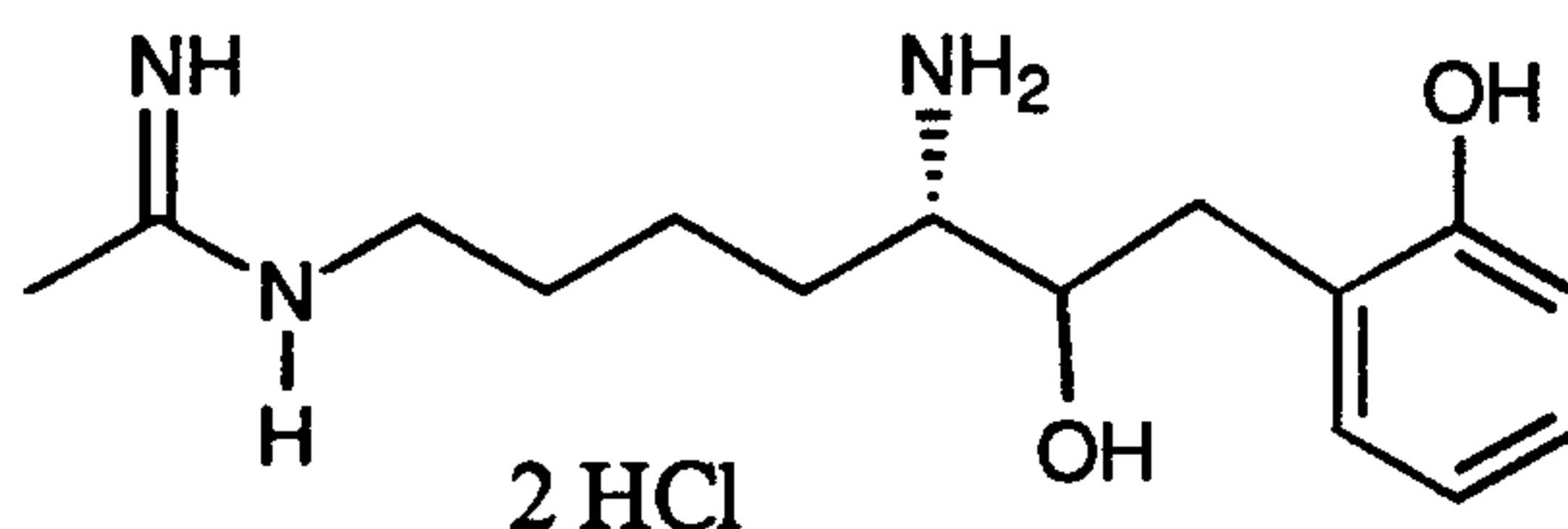
10

37. A solution of **36** in 1 M aqueous HCl is refluxed for two hours. The reaction is stripped to small volume, shelled, and lyophilized to give the title compound.

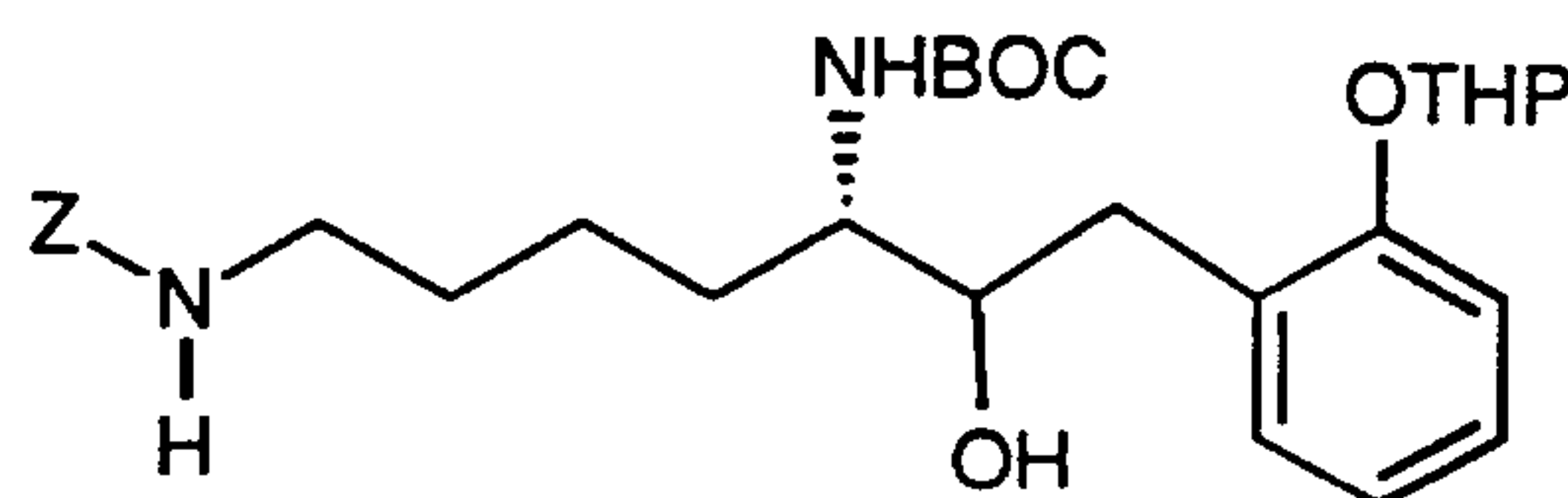
15

Example 38

N-[5S-amino-6-hydroxy-7-(2-hydroxyphenyl)heptyl]ethanimidamide, dihydrochloride

**38**

20

**38a**

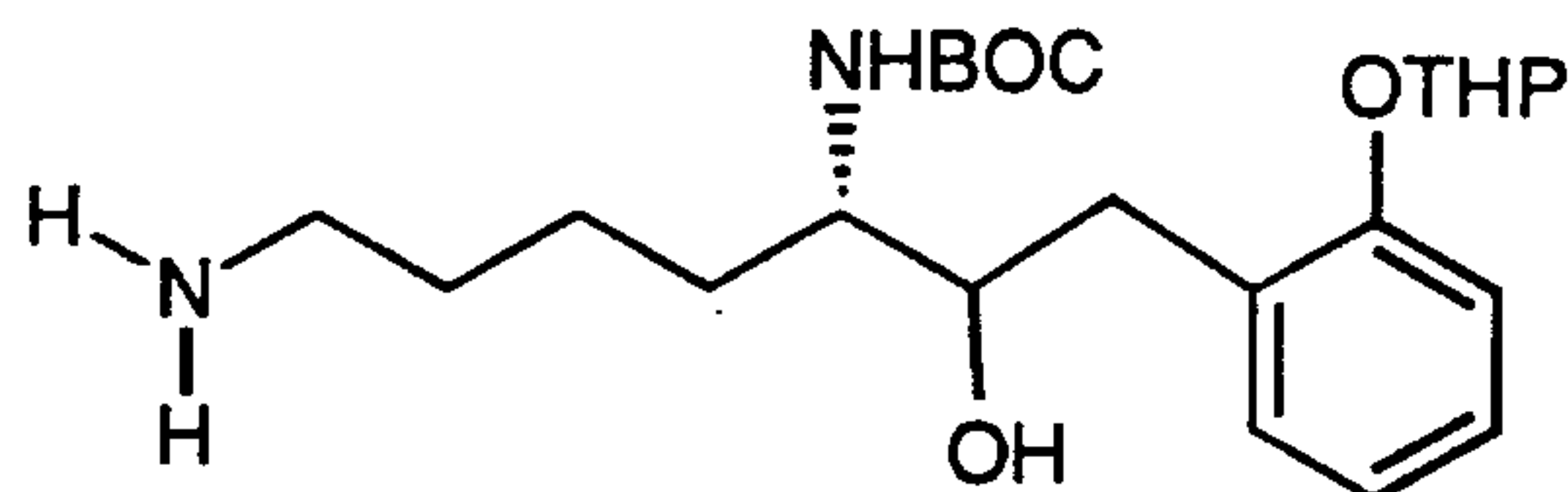
25

38a. 2-(Tetrahydropyran-2-yloxy)phenyllithium is prepared from 2-(tetrahydropyran-2-yloxy)phenyl bromide and

73

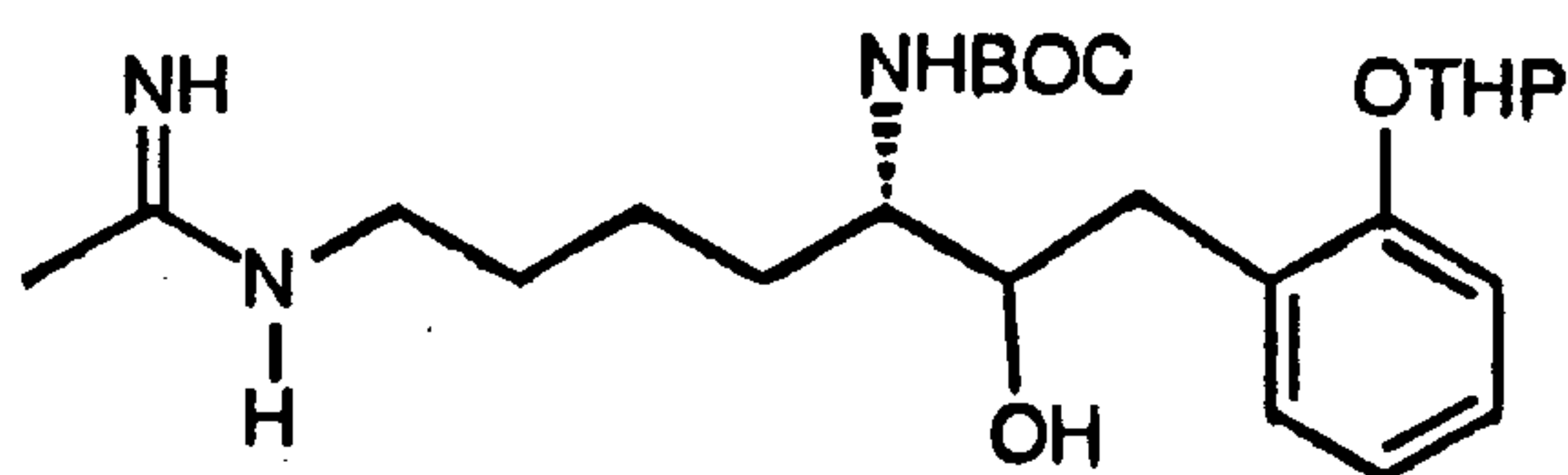
n-BuLi in THF at -78 °C. It is then reacted with **23a** in THF at -78 °C, allowing the temperature to rise to ambient temperature. The reaction mixture is worked up in the usual way to yield **38a**.

5

**38b**

38b. A solution of **38a** in AcOH is treated with H₂ (5 psi) over Pd black for 20 h. The reaction mixture is filtered and concentrated *in vacuo* to yield **38b**.

10

**38c**

15

38c. An equimolar solution of **38b** and ethyl acetimidate hydrochloride in EtOH is stirred for 18 h. The reaction solution is concentrated *in vacuo* to yield a white foam. This material is purified by reversed phase HPLC to yield **38c**.

20

38. To a stirred solution of **38c** in AcOH (glacial) is added HCl (6.95 M in dioxane). The resulting solution is stirred for 2 h. The solution is concentrated *in vacuo* and triturated with diethyl ether to yield **38**.

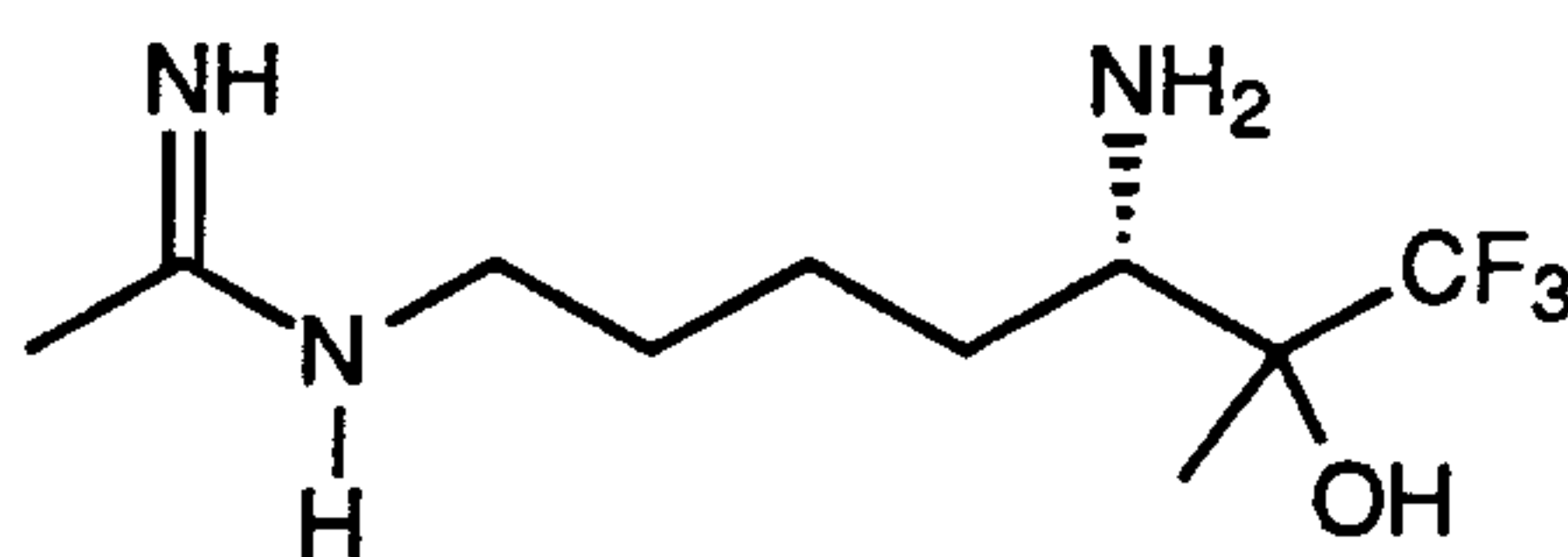
25

Example 39

N-[5S-amino-7,7,7-trifluoro-6-hydroxy-6-methylheptyl)ethanimidamide

30

74

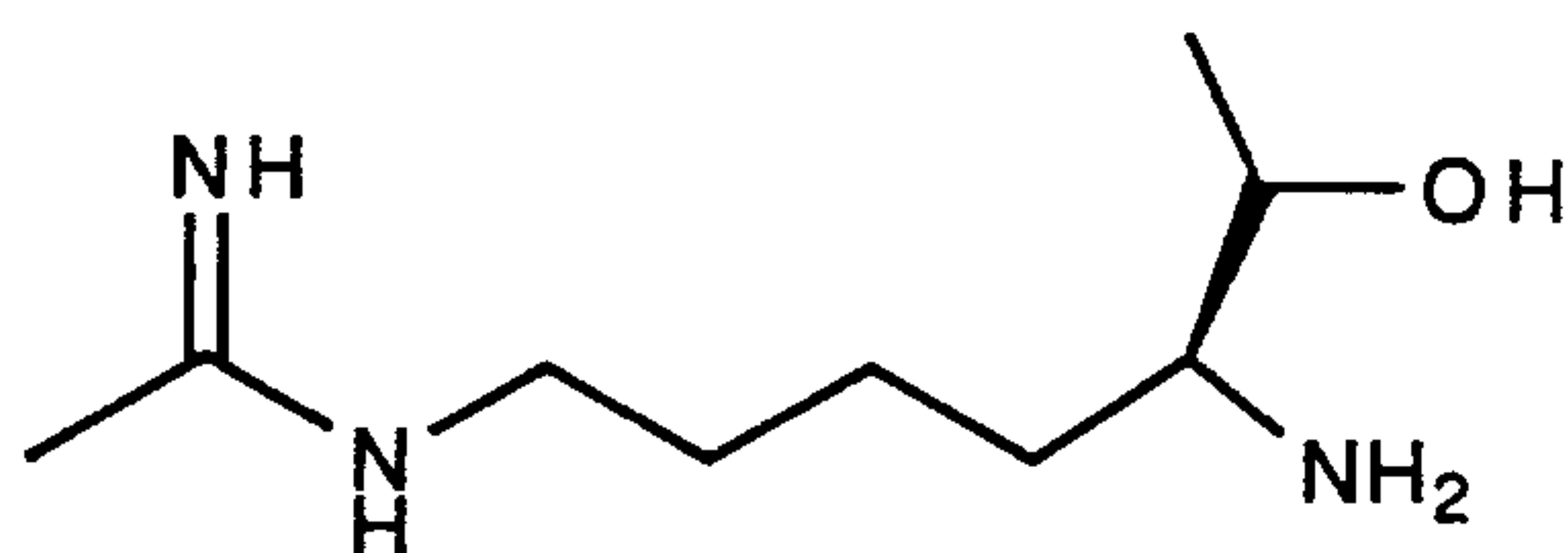


39a. To a stirring solution of CF_3I (10 mmol) in 5 mL of DMF at -40°C is added Zn (10 mg-atm) and **14a** (0.5 mmol) in 10 mL of DMF. After stirring for 1 h at -20°C , the reaction is warmed to room temperature and partitioned between H_2O and EtOAc. The organic layer is worked up in the usual manner to obtain desired trifluoromethyl alcohol.

39. Using conditions described in example 3, the desired compound is obtained.

Example 40

N-(5S-amino-6-hydroxyheptyl)ethanimidamide, dihydrochloride dihydrate



40A, 40B

40a. To a 50 mL solution of **14a** (1.5 g, 4.0 mmol) in EtOH was added NaBH_4 . After 2h, the reaction was concentrated under vacuum. The residue was taken up in 50 mL of EtOAc and 30 mL of H_2O . The organic was treated in the usual manner to obtain 1.5 g of **40a**.

40A, 40B. Examples **40A**, **40B** were prepared in same manner as described in example 15. The first eluting fractions from the final purification by reverse phase chromatography were a single isomer (**40A**). The second eluting fractions were a mixture of two isomers (**40B**). **40A** Analysis calcd.

75

for $C_9H_{21}N_3O \cdot 2 HCl \cdot 2 H_2O$: C, 36.49; H, 9.19; N, 14.18.

Found: C, 36.73; H, 8.93; N, 14.13. **40B** Analysis calcd.

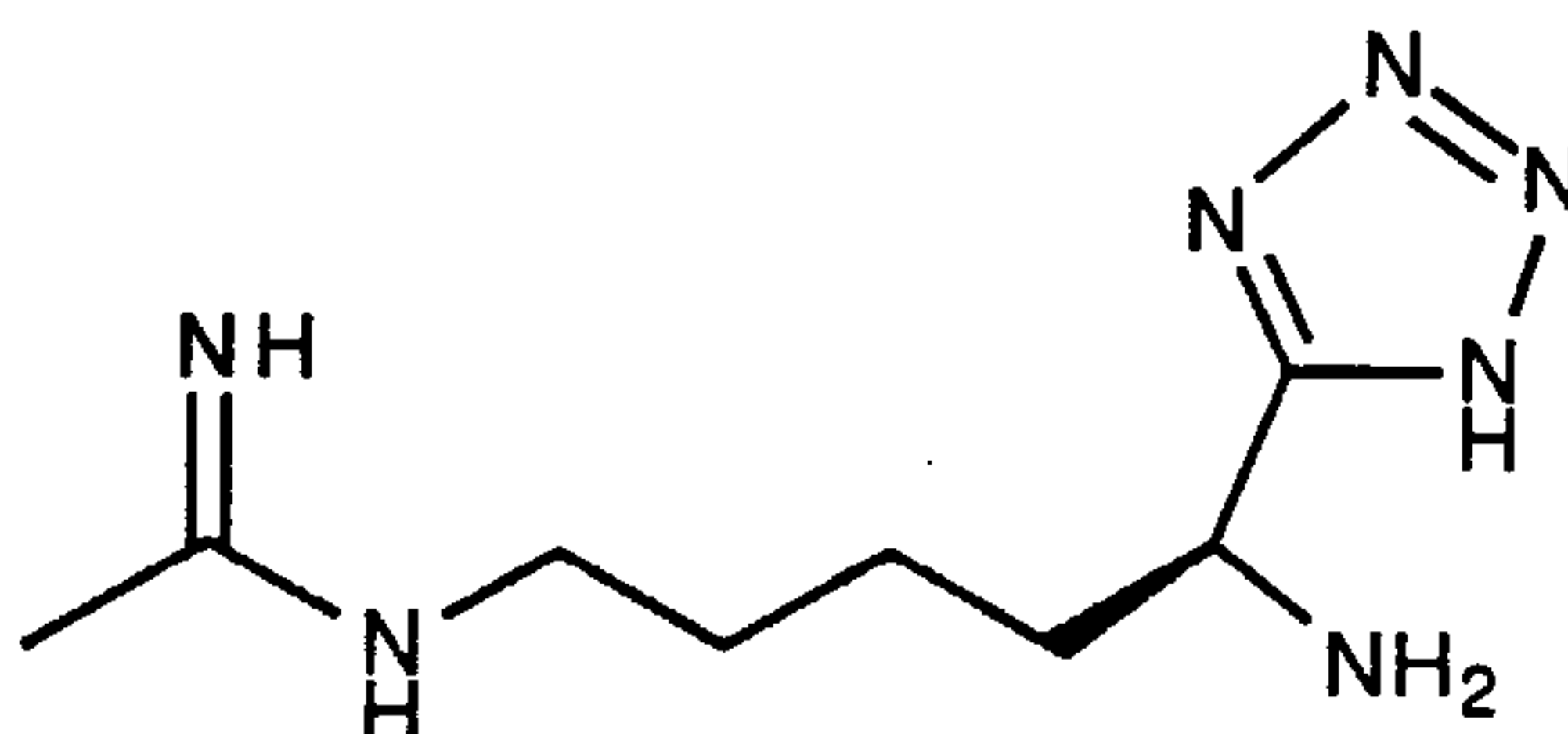
for $C_9H_{21}N_3O \cdot 3 HCl \cdot 2 H_2O$: C, 32.49; H, 8.48; N, 12.63.

Found: C, 32.37; H, 8.08; N, 12.04.

5

Example 41

N-[5S-amino-5-(1H-tetrazol-5-yl)pentyl]ethanimidamide, dihydrochloride



10

41a. To a stirring solution of N- α -Boc-N- ϵ -Z-L-Lys. (3.8 g, 10 mmol), 2-aminopropionitrile fumarate (1.9 g, 10 mmol), 1-hydroxybenzotriazole hydrate (4.4 g, 10 mmol), and NMM (3.3 mL, 30 mmol) in 50 mL of DMF cooled in an ice bath was added (1H-1,2,3-benzotriazol-1-yl)oxy)-tris(dimethylamino)phosphonium hexafluorophosphate (BOP) (4.4 g, 10 mmol). After stirring 18 h at ambient temperature, the filtrate was concentrated under vacuum.

41b. To a stirring solution of **41a** (3.9 g, 9 mmol) in 90 mL of THF was added PPh_3 , DEAD, $TMSN_3$. After 24 h of stirring at ambient temperature, the reaction was cooled to 0 °C to which was added slowly 300 mL of 6% $Ce(NH_4)_2(NO_3)_6$.

Additional $Ce(NH_4)_2(NO_3)_6$ was added until evolution of N_2 ceased. The layers were separated and the aqueous layer was

25

30

extracted 2x 250 mL of DCM. The combined organic layers were treated in the usual manner to yield 3.1 g of **41b**.

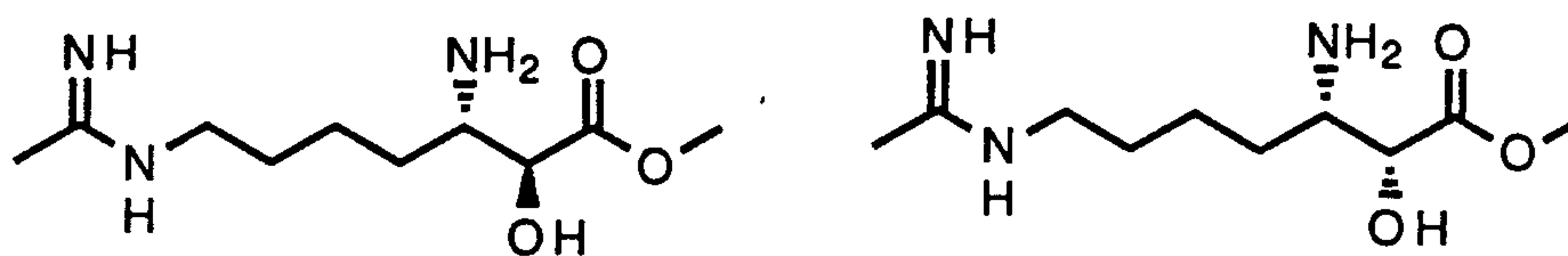
41c. To a stirring solution of **41b** (2.7 g, 5.9 mmol) in 60 mL of THF was added 7 mL of 1N NaOH. After 18 h, the reaction was concentrated under vacuum. The residue was taken up in 50 mL of EtOAc and 50 mL of 0.5N NaOH. The layers were separated and the aqueous layer was washed 2x 50 mL of EtOAc. The aqueous layer was acidified to pH 3 and extracted 3x 40 mL EtOAc. The second organic extractions were worked up in the usual manner to obtain 0.3 g of **41c**. The original organic extracts were worked up in the usual manner and they also contained product (2 g).

41. To obtain example **41**, conditions described in example 3 were used.

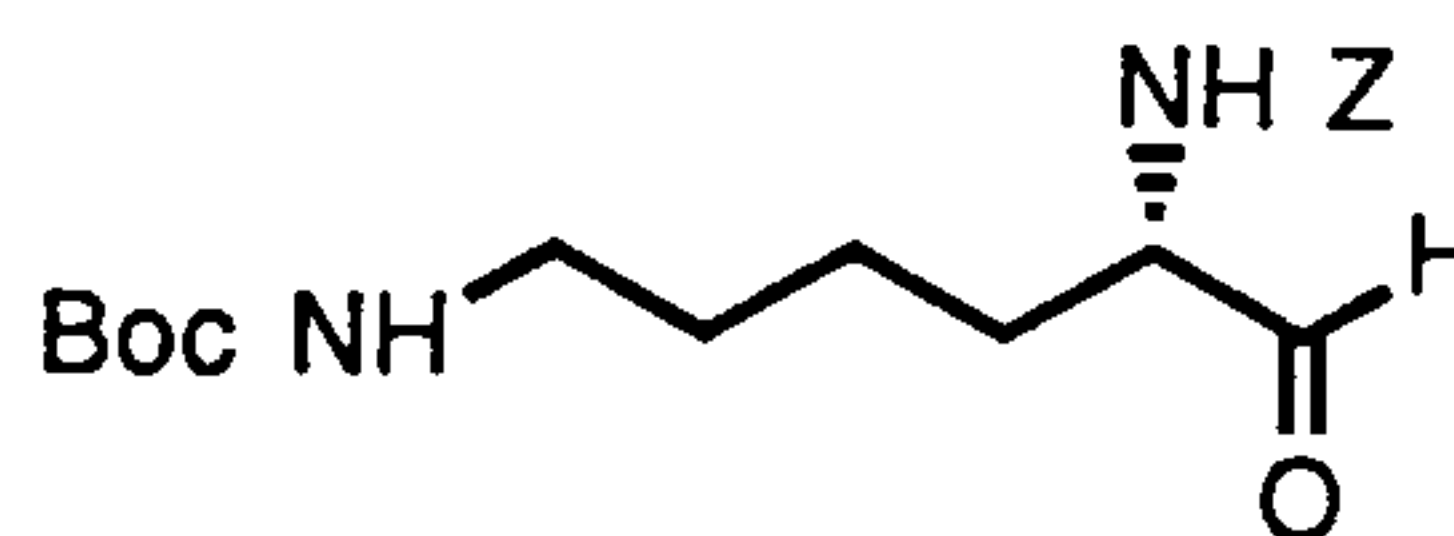
Example 42

(A) methyl 3S-amino-2S-hydroxy-7-[(1-iminoethyl)amino]heptanoate

(B) methyl 3S-amino-2R-hydroxy-7-[(1-iminoethyl)amino]heptanoate



42A, 42B

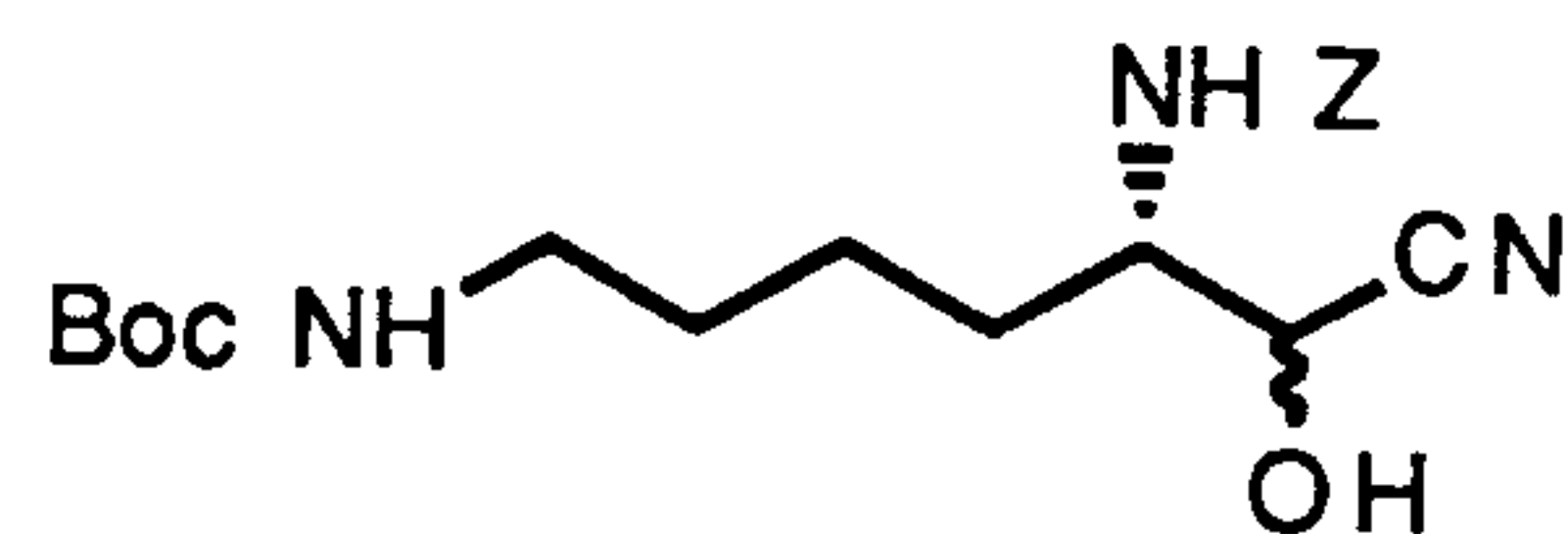


42a

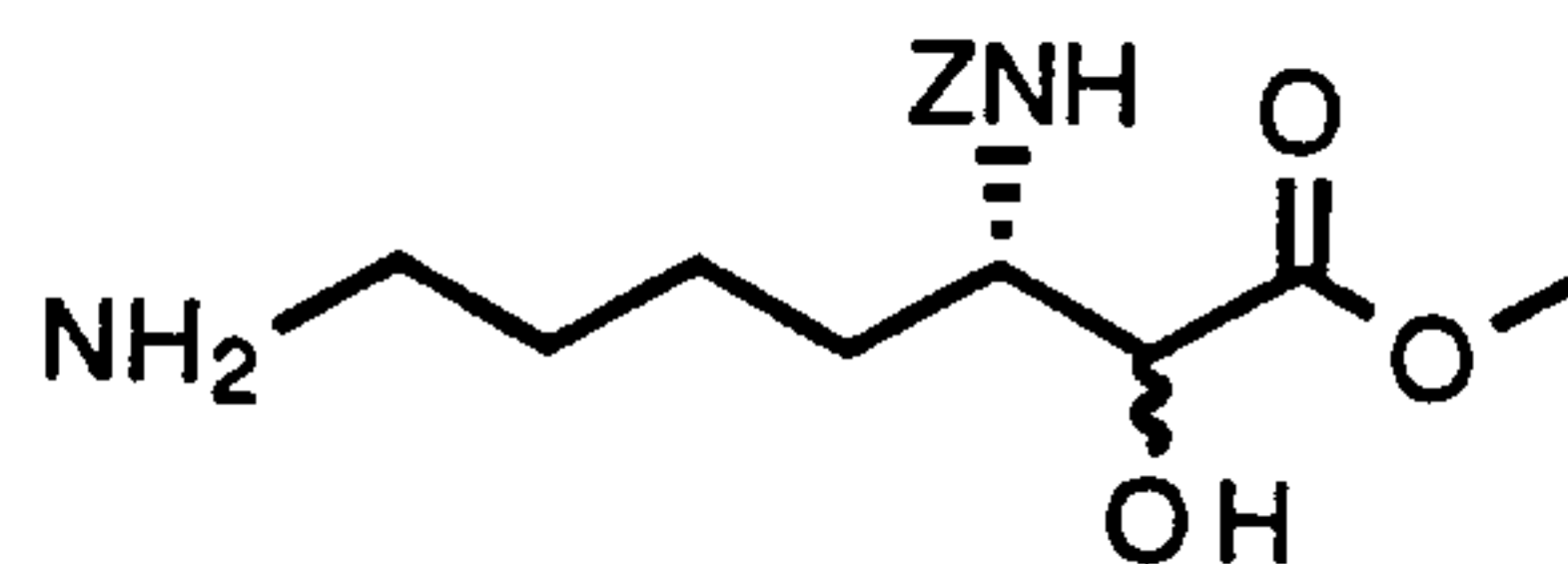
42a. To a stirring solution of N-α-Z-N-ε-Boc-L-Lys-N(OMe)Me **11a** in ether at 0°C is added LiAlH₄ (1.2 equiv.) in portions. The resulting solution is stirred for 1h at

77

0°C, then carefully quenched with KHSO₄ (1 M). The layers are separated and the aqueous extracted with ether. The combined organic solutions are extracted with KHSO₄ (1 M) and NaHCO₃ (satd.) dried (Na₂SO₄) and evaporated to yield the aldehyde **42a**, which is used directly in the next step.

**42b**

42b. A stirred mixture of the aldehyde **42a** in EtOAc and KCN (1 equiv.) in water, at 0°C, is treated with an aqueous solution of NaHSO₃ (satd.). The solution is stirred for 1 h, and the layers separated. The organic solution is dried over Na₂SO₄ anhydrous and concentrated to yield the resulting cyanohydrin **42b**.

**42c**

20

42c. The cyanohydrin **42b** is treated with methanolic/HCl to yield the methyl ester **42c**.

42A, 42B. The amine **42c** is treated with methyl acetimidate according to the procedure for **11e**. The product is then treated with Pd black according to the procedure for **11**, and the isomers separated on reversed phase HPLC to yield **42A** and **42B**.

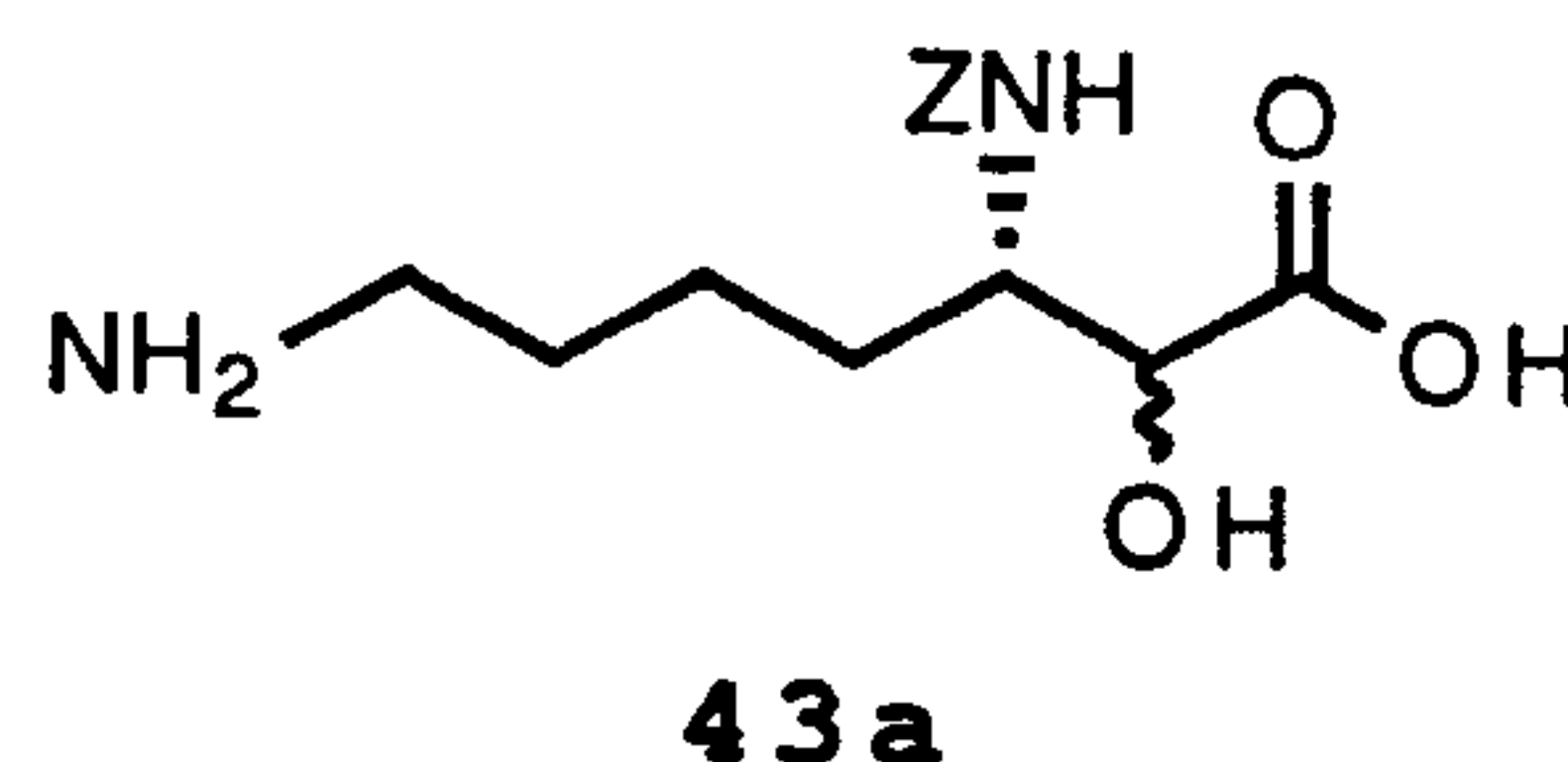
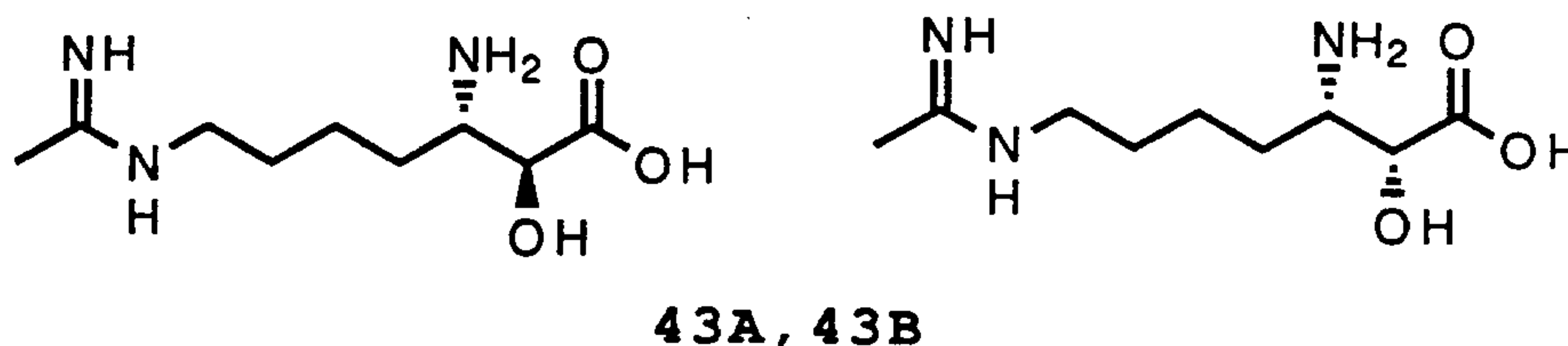
30

Example 43

78

(A) 3S-amino-2S-hydroxy-7-[(1-iminoethyl)amino]heptanoic acid

(B) 3S-amino-2R-hydroxy-7-[(1-iminoethyl)amino]heptanoic acid



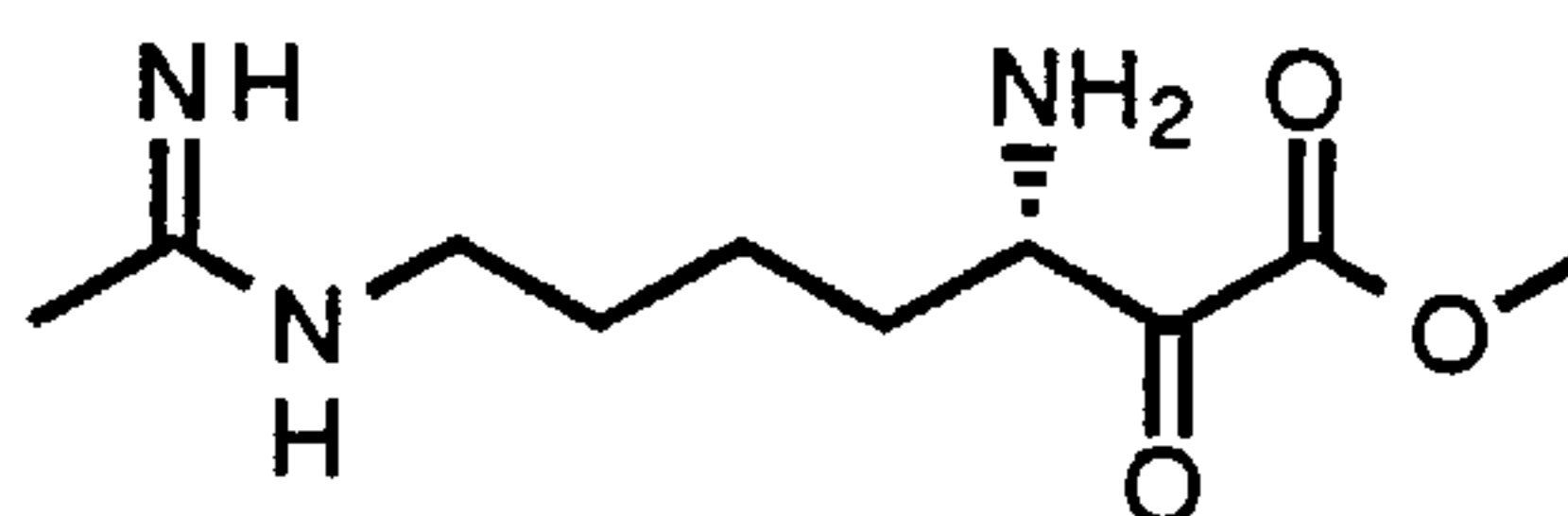
43a. The cyanohydrin **42b** is treated with concentrated HCl at 0°C for 12 h. The solution is concentrated under vacuum and the ammonium chloride is removed by filtration. The residue is then dried to yield the hydroxy acid **43a**.

43A, 43B. The amine **43a** is treated with methyl acetimidate according to the procedure for **11e**. The product is then treated with Pd black according to the procedure for **11**, and the isomers separated on reversed phase HPLC to yield **43A** and **43B**.

25

Example 44

methyl 3S-amino-7-[(1-iminoethyl)amino]-2-oxoheptanoate



79

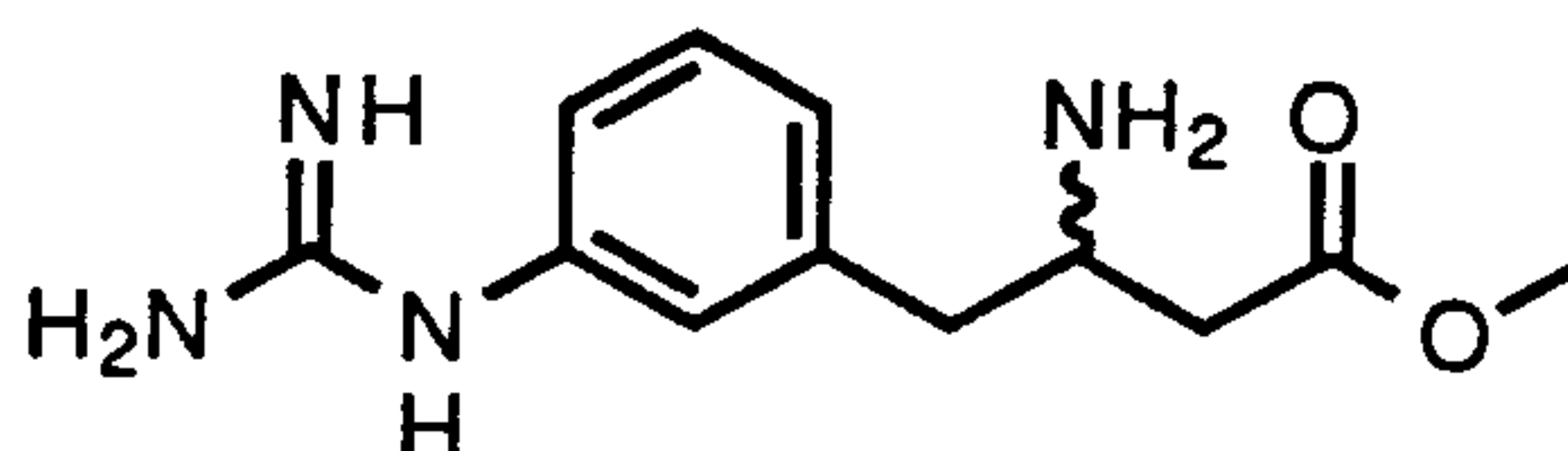
44

44. A solution of 42A and 42B in water is treated with MnO₂. The solution is filtered and concentrated to yield 5 44.

Example 45

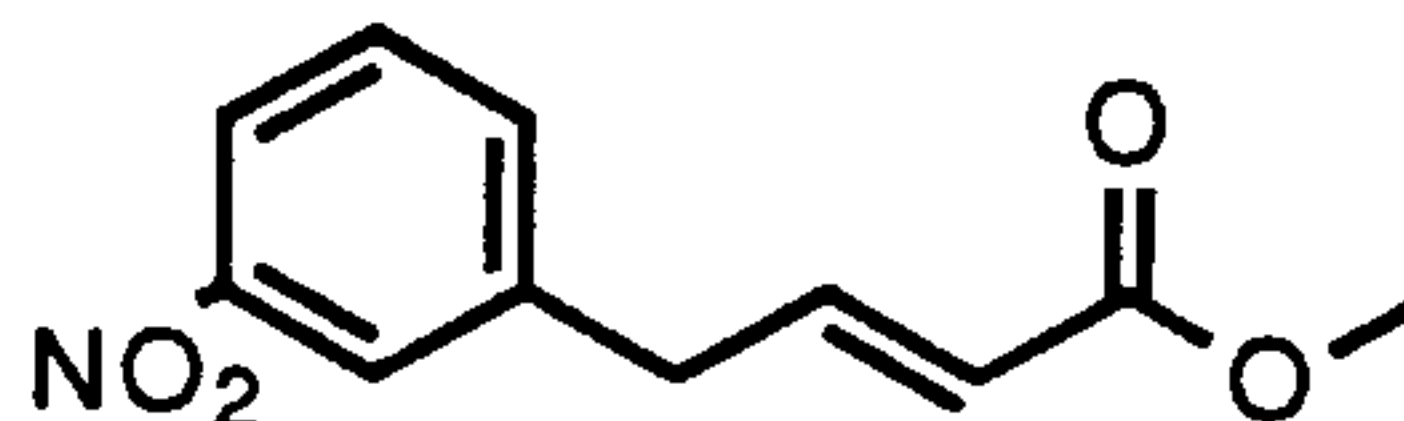
methyl 3-amino-4-[3-
[(aminoiminomethyl)amino]phenyl]butanoate

10



45

15



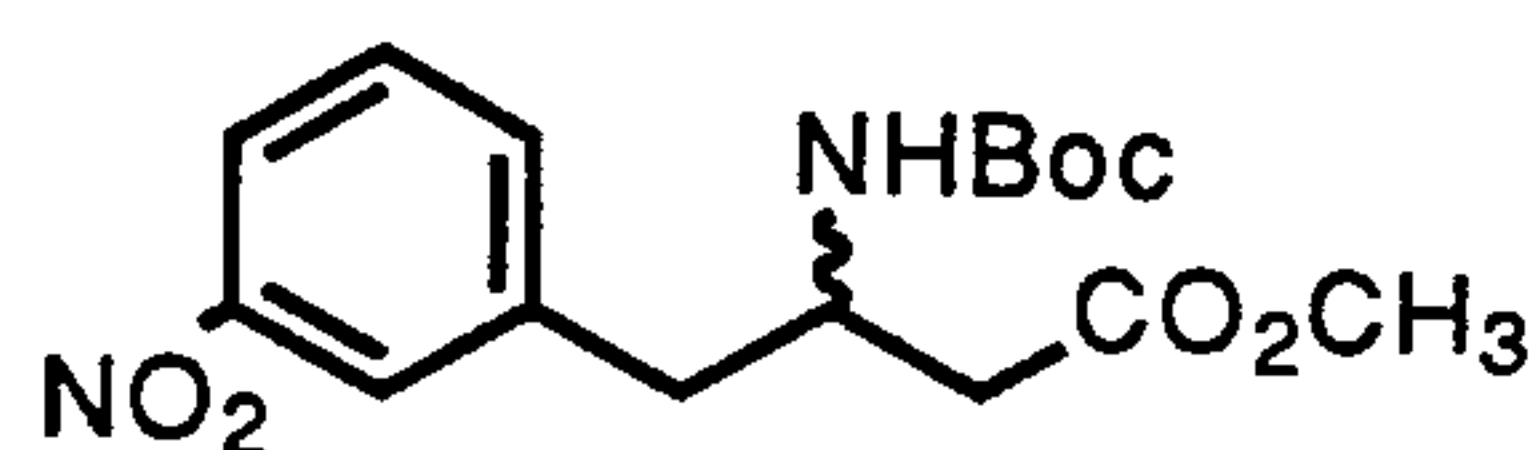
45a

45a. To a stirred solution of oxalyl chloride (1.1 equiv.) in dry CH₂Cl₂ is slowly added at -60°C a solution of dry DMSO in CH₂Cl₂. After the solution is stirred for 5 min a solution of 3-nitrophenethyl alcohol (1 equiv.) in dry CH₂Cl₂ is added. The solution is stirred for an additional 15 min and subsequently TEA is added. After stirring for 5 min the cooling bath is removed and the solution is allowed to reach room temperature. The reaction is quenched with water. The organic layer is removed and the aqueous layer extracted with additional CH₂Cl₂. The combined organic extracts are washed with brine and water, dried (Na₂SO₄) and 30 evaporated to yield the aldehyde. The aldehyde is treated with

80

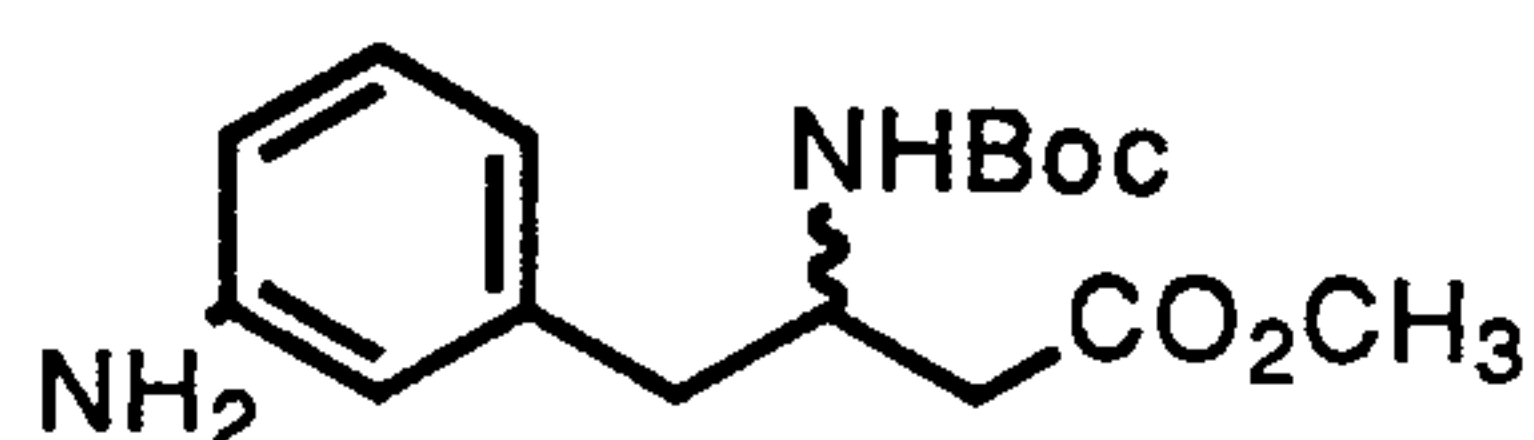
carbomethoxymethyl)triphenylphosphonium bromide by the method of **17a**, to yield the ester **45a**.

5

**45b**

45b. A solution of **45a** and ammonium chloride (3 equiv.) in glacial acetic acid is refluxed for 3 h. The solvent is removed in vacuo and the residue is partitioned between EtOAc and aqueous Na₂CO₃. The layers are separated and the organic phase is dried (Na₂SO₄) and evaporated to yield the amine. The residue is taken up in THF and treated with di-*t*-butyl dicarbonate (1.5 equiv.) and triethylamine (1.1 equiv.). The resulting solution is refluxed for 2 h, concentrated in vacuo and purified by flash column chromatography to yield **45b**.

20

**45c**

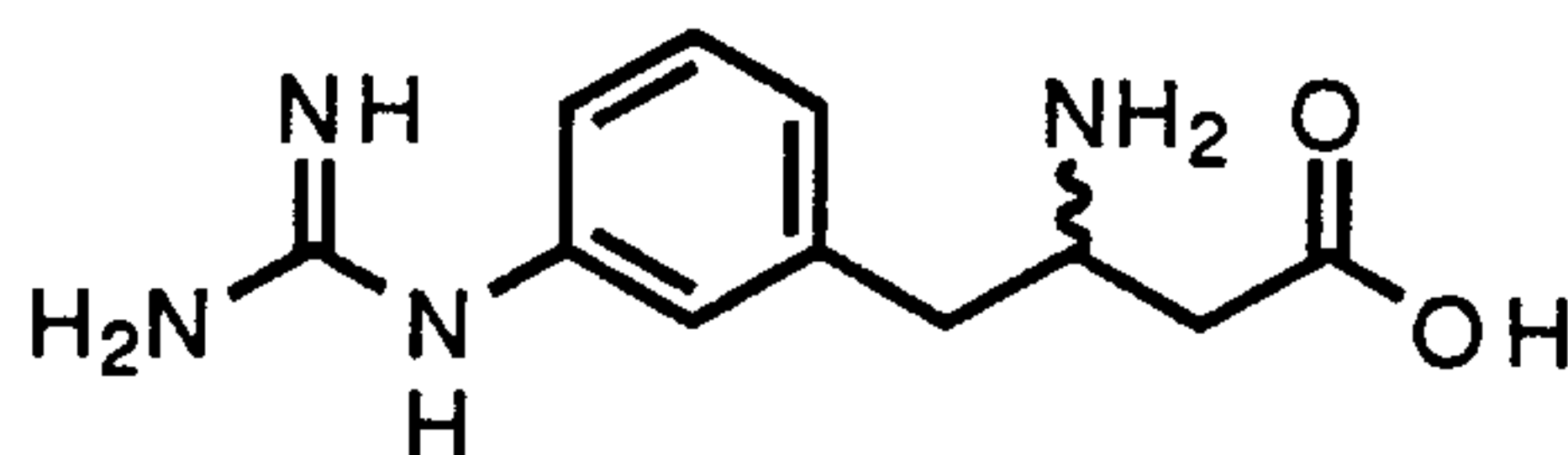
45c. A solution of **45b** in methanol is hydrogenated in the presence of 10% Pd/C to yield **45c**.

45. Aminoiminomethanesulphonic acid (1.1 equiv.) is added to a solution of **45c** in methanol. The solution is stirred for 24 h. The solvent is removed and the residue is dissolved in water. The pH is adjusted to greater than 7 with NaOH. The mixture is extracted with EtOAc, dried (Na₂SO₄) and concentrated in vacuo. The residue is then treated with methanol/HCl to yield **45**.

81

Example 46

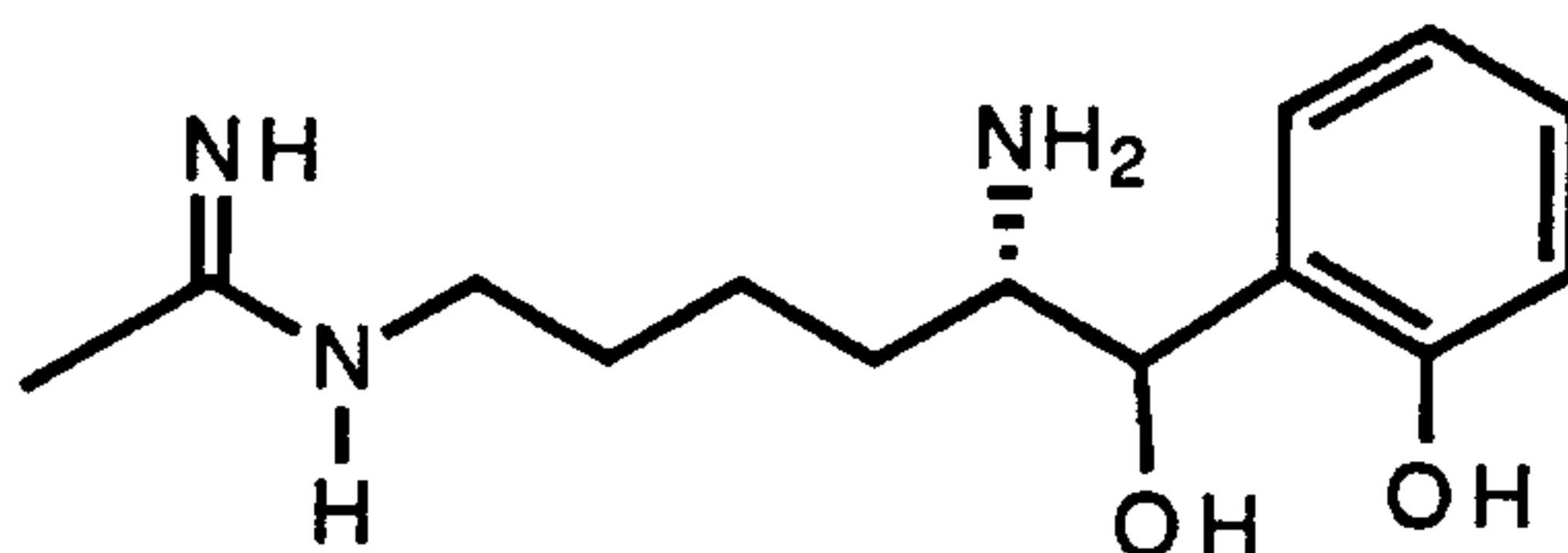
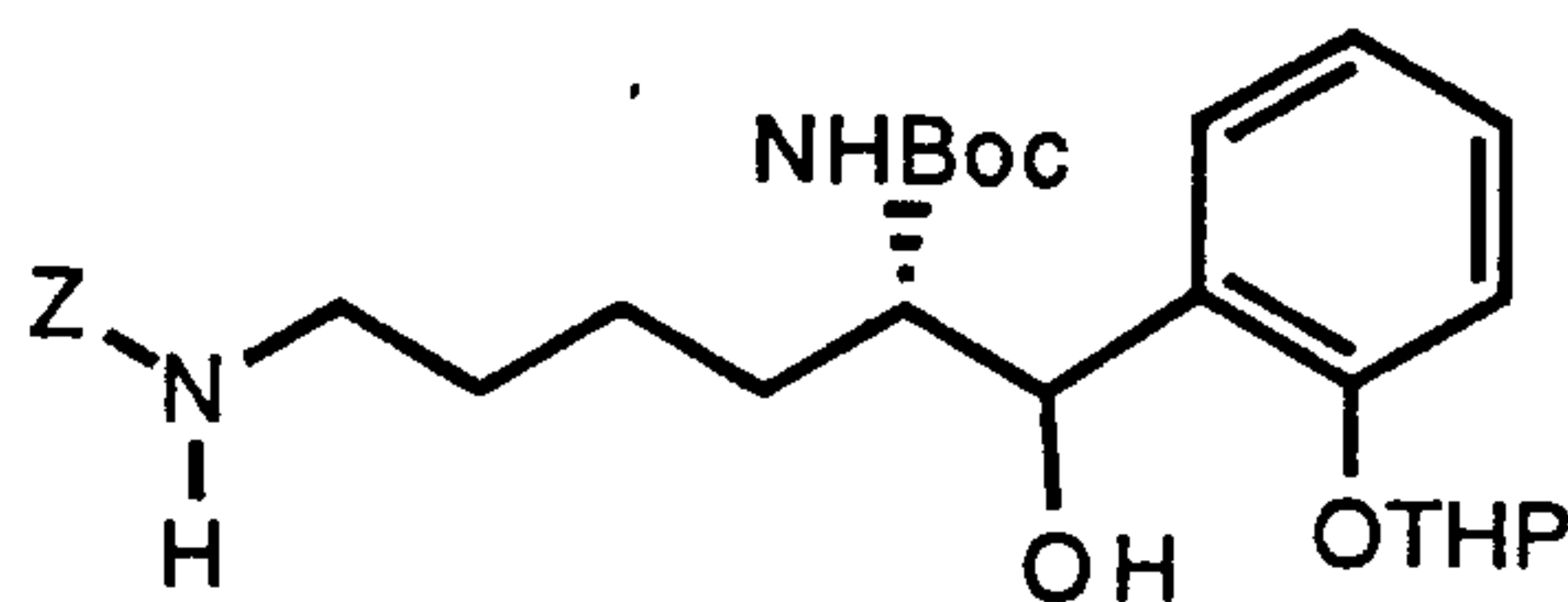
**3-amino-4-[3-
[(aminoiminomethyl)amino]phenyl]butanoic acid**

**46**

46. **45** is dissolved in 2N HCl and refluxed for 1 h. The reaction is diluted with water and lyophilized to yield **46**.

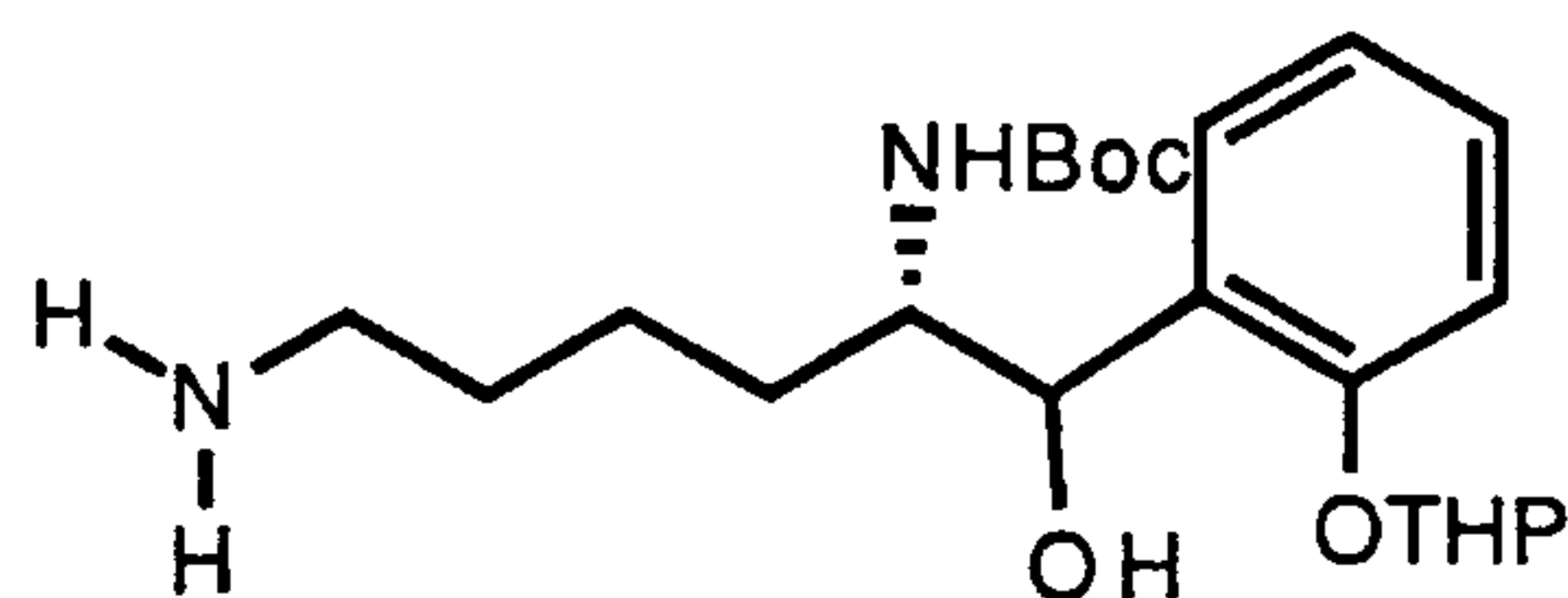
Example 47

N-[5S-amino-6-hydroxy-6-(2-hydroxyphenyl)hexyl]ethanimidamide

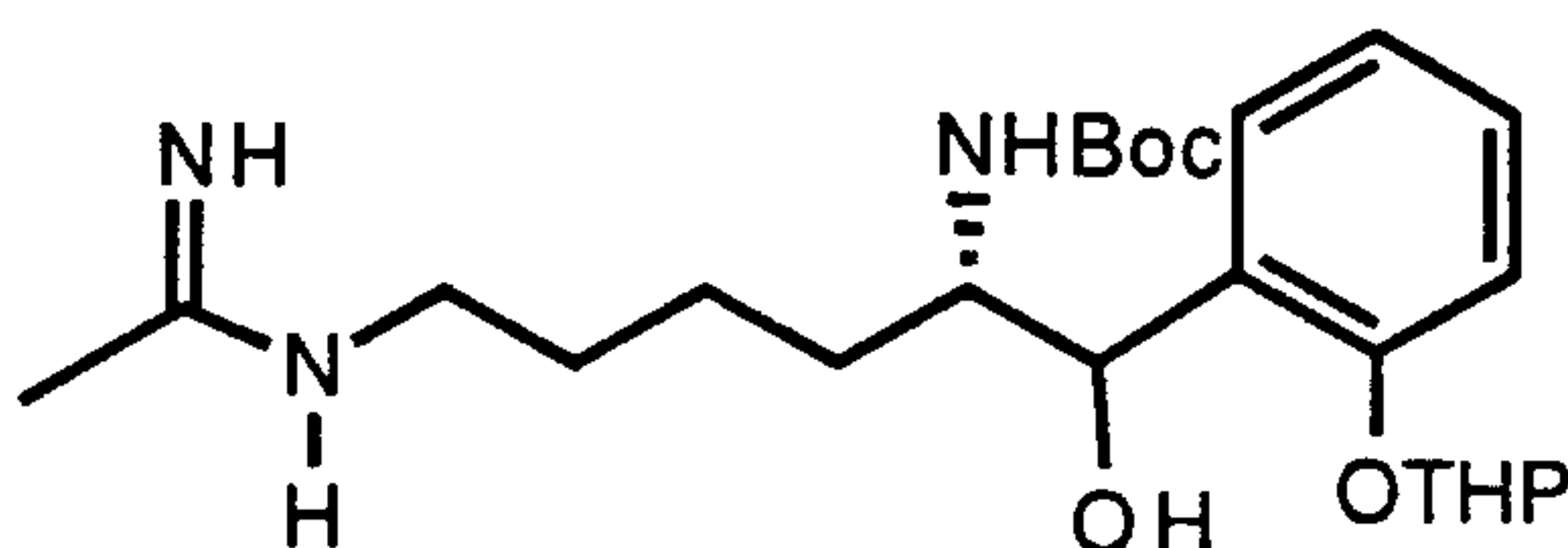
**47****47a**

47a. 2-(Tetrahydropyran-2-yloxy)phenyllithium is prepared from 2-(tetrahydropyran-2-yloxy)phenyl bromide and n-BuLi in THF at -78 °C. It is then reacted with **3b** in THF at -78 °C, allowing the temperature to rise to ambient temperature. The reaction mixture is worked up in the usual way to yield **47a**.

82

**47b**

5 **47b.** A solution of **47a** in AcOH is treated with H₂ (5 psi) over Pd black for 20 h. The reaction mixture is filtered and concentrated *in vacuo* to yield **47b**.

**47c**

10

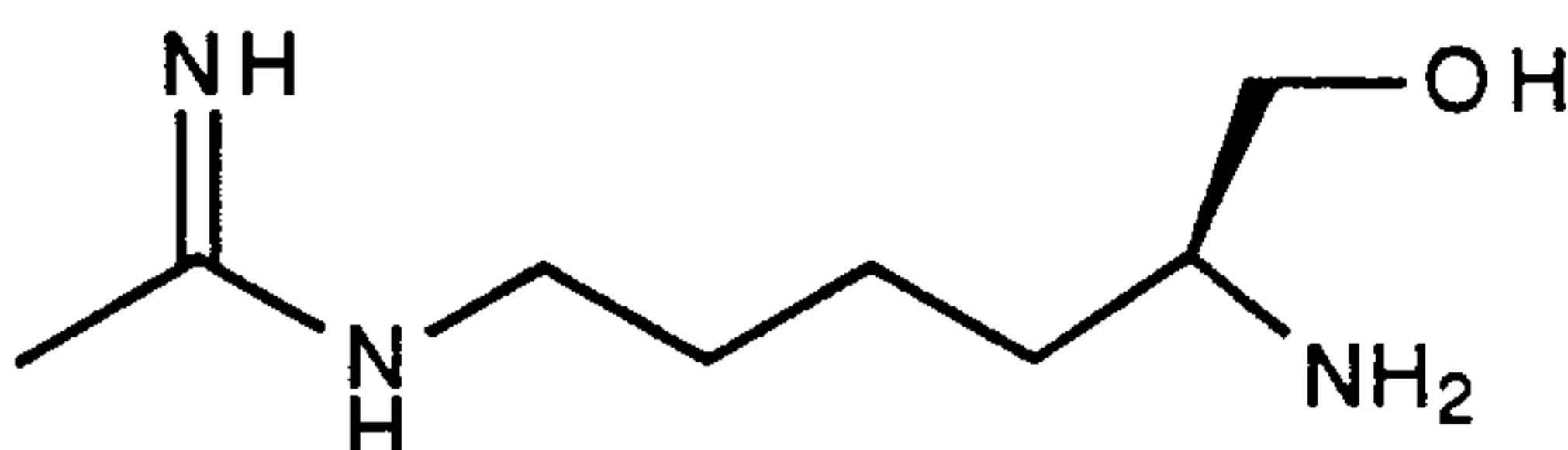
47c. An equimolar solution of **47b** and ethyl acetimidate hydrochloride in EtOH is stirred for 18 h. The reaction solution is concentrated *in vacuo* to yield a
15 white foam. This material is purified by reversed phase HPLC to yield **47c**.

47. To a stirred solution of **47c** in AcOH (glacial) is added HCl (6.95 M in dioxane). The resulting solution is
20 stirred for 2 h. The solution is concentrated *in vacuo* and triturated with diethyl ether to yield **47**.

Example 48

N-(5S-amino-6-hydroxyhexyl)ethanimidamide

25

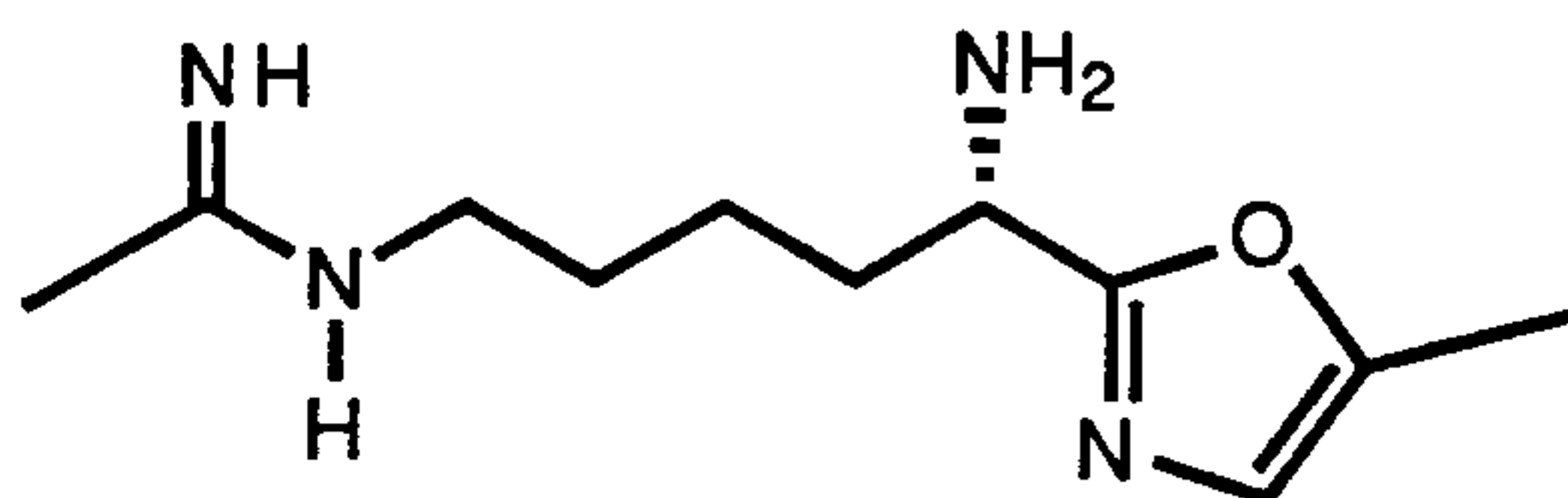
**48**

48. Example 48 was prepared using methods described in example 3 starting with 3c. h.r.m.s. $C_8H_{19}N_3O$: 174.16.

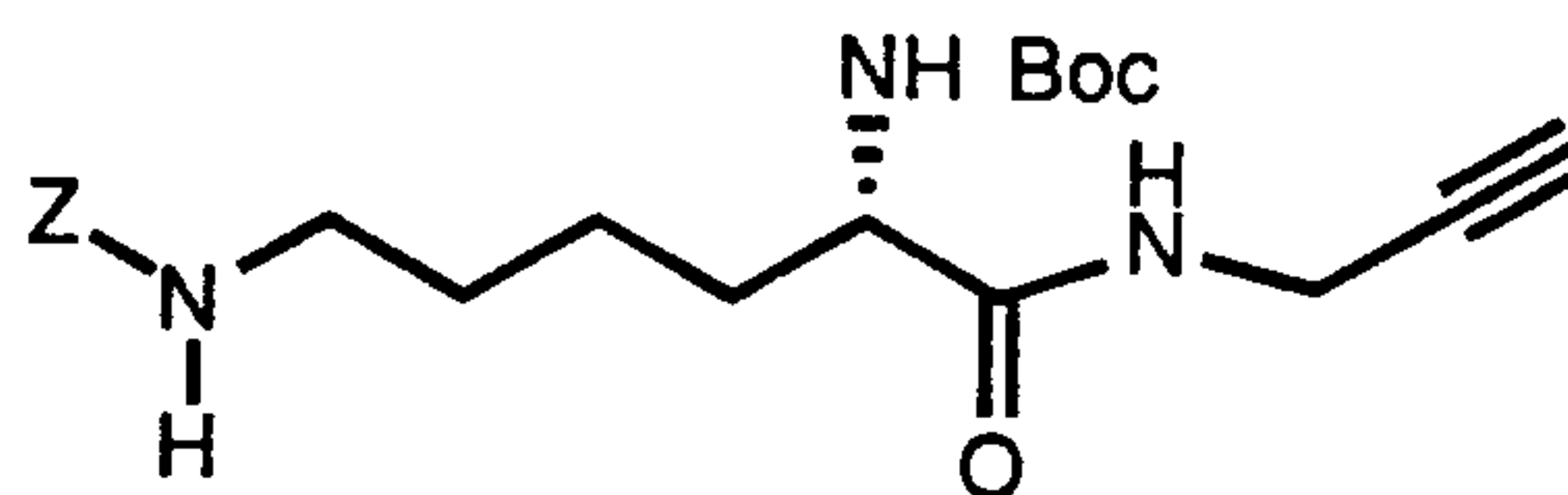
5

Example 49

N-[5-amino-5-(5-methyloxazol-2-yl)pentyl]ethanimidamide, hydrochloride hydrate

**49**

10

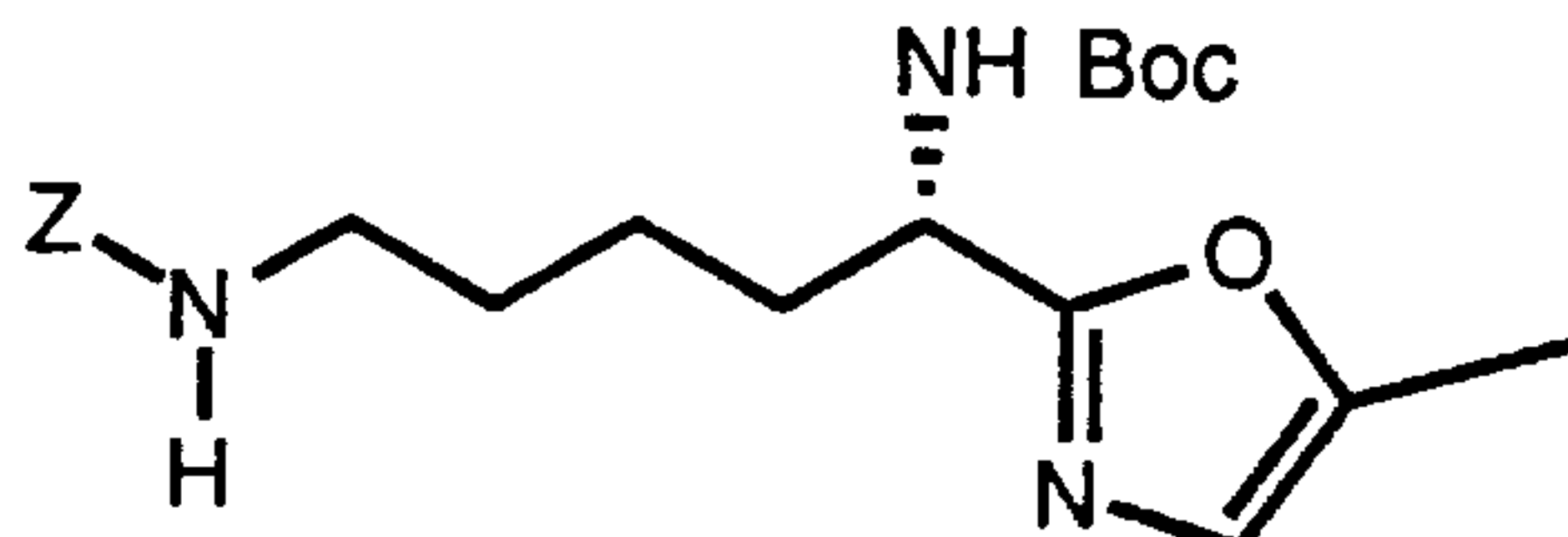
**49a**

15

To a cooled (0°C) solution of N- α -Boc-N- ϵ -Z-Lys (3.8 g, 10 mmol), propargylamine (550 mg, 10 mmol) and Et₃N (1 g, 10 mmol) in DMF was added HOBT (1.35 g, 10 mmol) and EDC (1.92 g, 10 mmol). The solution was allowed to gradually warm to RT over 16 h. EtOAc (500 mL) was added to the reaction solution followed by extraction with brine (4 x 100 mL), dried (Na₂SO₄) and concentrated to yield an oil. The product was crystallized from ether/hexane to yield **49a** (4.3 g) as a white solid. Anal. Calcd for C₂₂H₃₁N₃O₂: C, 63.29; H, 7.48; N, 10.06. Found: C, 63.04; H, 7.41; N, 9.94.

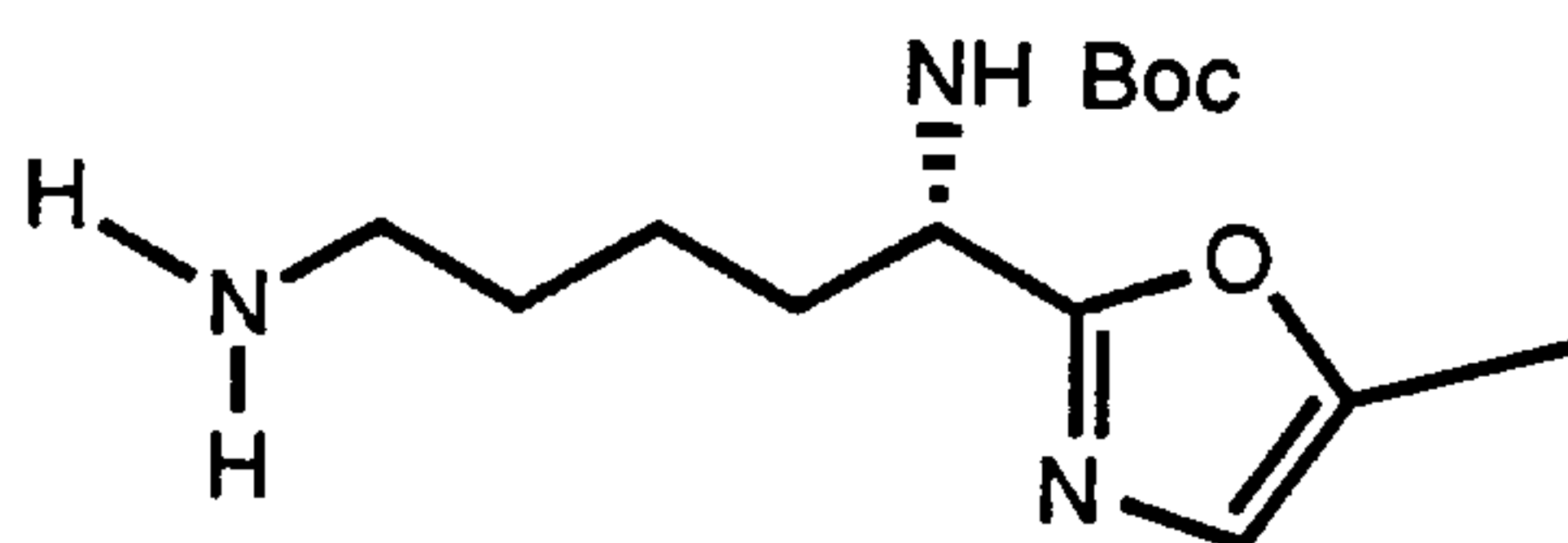
20

25

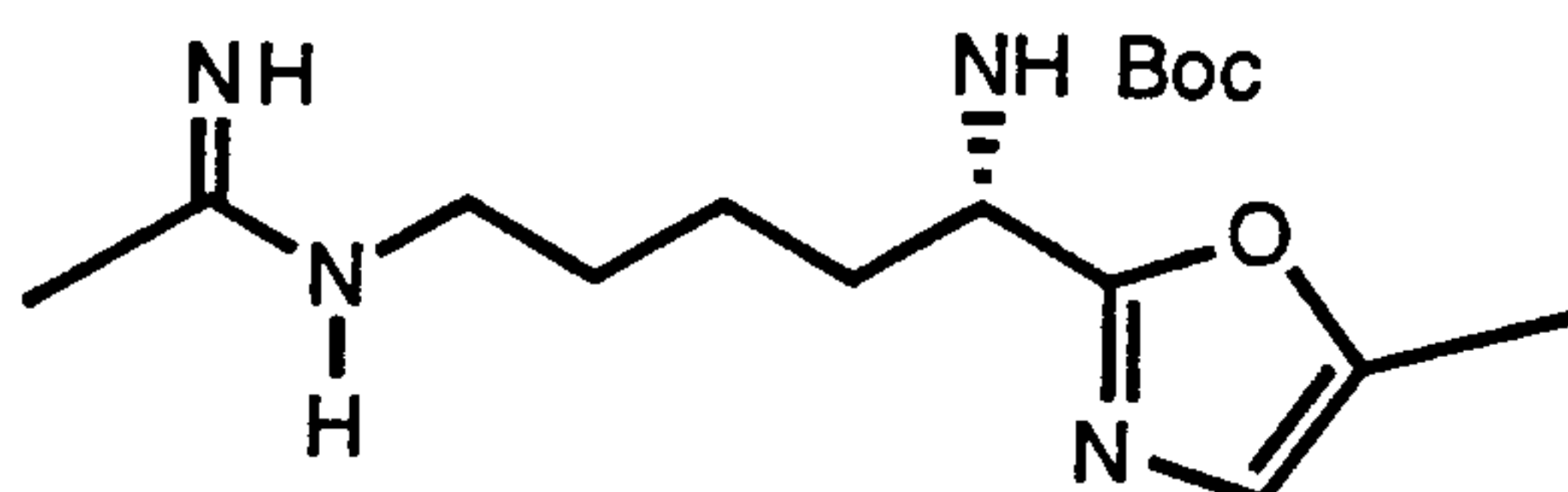
**49b**

84

A solution of **49a** (1.8 g, 4.3 mmol) and mercuric acetate (240 mg, .8 mmol) in AcOH (80 mL) was refluxed for 2 h. The solution was stirred at RT for 2h. The solvent was removed and the residue taken up in CHCl₃ (250 mL) and washed with NaOH (1M, 1 x 100 mL) and brine (100 mL), dried (Na₂SO₄) and evaporated to yield an oil. The product was purified by flash chromatography to yield **49b**. Anal. Calcd for C₂₂H₃₁N₃O₂ · 2 H₂O: C, 62.75; H, 7.52; N, 9.98. Found: C, 62.40; H, 7.40; N, 9.61.

**49c**

A solution of **49b** (2.0 g, 4.75 mmol) in ethanol was treated with H₂ (5 psi) over Pd/C (10%) for 3 h. The reaction mixture was filtered and concentrated *in vacuo* to yield **49c**.

**49d**

An equimolar solution of **49c** (1.0 g, 3.5 mmol) and ethyl acetimidate hydrochloride in EtOH was stirred for 18 h. The reaction solution is concentrated *in vacuo* to yield a white foam (1.2 g).

49. To a stirred solution of **49d** (1.2 g, 3.3 mmol) in AcOH (glacial, 25 mL) was added HCl (5.8 M in dioxane, 3 mL). The resulting solution was stirred for 1 h. The solution is

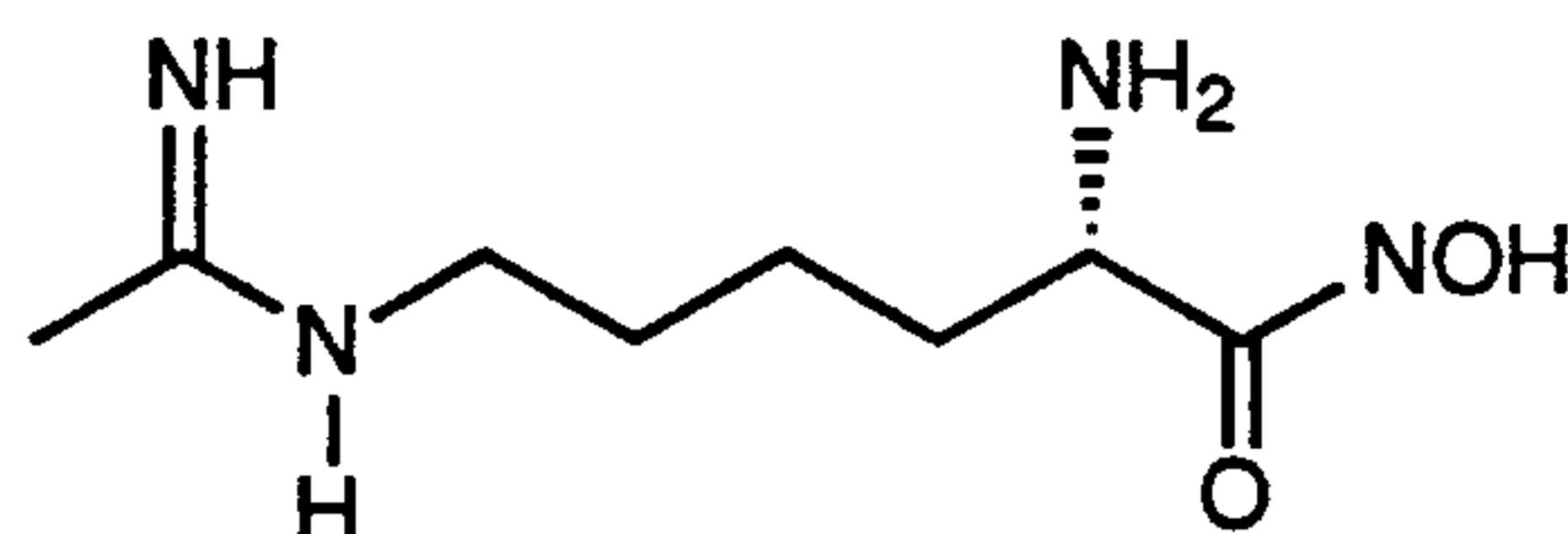
85

concentrated *in vacuo* and purified by reversed phase HPLC to yield **49**. Anal. Calcd for $C_{11}H_{20}N_4O \cdot 2.1 HCl \cdot 1.6 H_2O$: C: 40.07; H: 7.74; N:16.99; Cl:22.58. Found: C: 40.33; H: 8.00; N: 16.68, Cl: 22.75.

5

Example 50

2S-amino-N-hydroxy-6-[(1-iminoethyl)amino]hexanamide, hydrochloride



10

50a. Starting with N- α -Z-N- ϵ -Boc-Lys and O-benzylhydroxylamine hydrochloride example **50** was synthesized using conditions described in examples **11a**, **11c-e**, **11**. Anal. Calcd for $C_8H_{18}N_4O_2 \cdot 1.5 HCl \cdot 0.25 HOAc \cdot H_2O$: C: 35.21; H: 7.82; N:19.32. Found: C: 35.32; H: 7.81; N: 19.75.

15

Biological Data

20

The activity of the above listed compounds as NO synthase inhibitors has been determined in the following assays:

25 Citrulline Assay for Nitric Oxide Synthase

Nitric oxide synthase activity was measured by monitoring the conversion of L-[2,3-³H]-arginine to L-[2,3-³H]-citrulline (1,2). Human inducible NOS (hiNOS), human endothelial constitutive NOS (heNOS) and human neuronal constitutive NOS (hncNOS) were each cloned from RNA extracted from human tissue. The recombinant enzymes were

30

expressed in insect cells using a baculovirus vector. Enzyme activity was isolated from cell extracts and partially purified by DEAE-SepharoseTM chromatography (2). Mouse inducible NOS (miNOS) was prepared from an extract of LPS-treated mouse RAW 264.7 cells and rat brain constitutive NOS (rcNOS) was prepared from an extract of rat cerebellum. Both preparations were partially purified by DEAE-SepharoseTM chromatography (2). Enzyme and inhibitors were added to give a volume of 50 μ L in 50 mM Tris (pH 7.6) and the reaction initiated by the addition of 50 μ L of a solution containing 50mM Tris (pH 7.6), 2.0 mg/mL bovine serum albumin, 2.0 mM DTT, 4.0 mM CaCl₂, 20 μ M FAD, 100 μ M tetrahydrobiopterin, 0.4- 2.0 mM NADPH and 60 μ M L-arginine containing 0.9 μ Ci of L-[2,3-³H]-arginine. For constitutive NOS, calmodulin was included at a final concentration of 40-100 nM. Following incubation at 37°C for 15 minutes, the reaction was terminated by addition of 300 μ L cold buffer containing 10 mM EGTA, 100 mM HEPES (pH5.5) and 1.0 mM L-citrulline. The [³H]-citrulline was separated by chromatography on DowexTM 50W X-8 cation exchange resin and radioactivity quantified with a liquid scintillation counter.

1. Bredt, D. S. and Snyder, S. H. (1990) *Proc. Natl. Acad. Sci. U.S.A.* 87, 682-685.
2. Misko, T. P., Moore, W. M., Kasten, T. P., Nickols, G. A., Corbett, J. A., Tilton, R. G., McDaniel, M. L., Williamson, J. R. and Currie, M. G. (1993) *Eur. J. Pharm.* 233, 119-125.

30

Raw Cell Nitrite Assay

RAW 264.7 cells are plated to confluency on a 96-well tissue culture plate grown overnight (17h) in the presence of LPS to induce NOS. A row of 3-6 wells are left untreated

35

and served as controls for subtraction of nonspecific background. The media is removed from each well and the cells are washed twice with Krebs-Ringers-Hepes (25mM, pH 7.4) with 2 mg/ml glucose. The cells are then placed on ice and incubated with 50 μ L of buffer containing L-arginine (30 μ M) +/- inhibitors for 1h. The assay is initiated by warming the plate to 37°C in a water bath for 1h. Production of nitrite by intracellular iNOS is linear with time. To terminate the cellular assay, the plate of cells is placed on ice and the nitrite-containing buffer removed and analyzed for nitrite using a previously published fluorescent determination for nitrite. All values are the average of triplicate wells and are compared to a background-subtracted induced set of cells (100% value).

15 The following examples were assayed with the following results.

88

Example number	hiNOS IC ₅₀ (μ M)	hecNOS IC ₅₀ (μ M)	hncNOS IC ₅₀ (μ M)	RAW cell i-NOS IC ₅₀	% inhibition iNOS at 100 μ M
1	61	1990	898	300	
2					*
1d					35
4					33
6					9
2d					5
3B	12.3	8420	150	80	
15A	9.3	2350	99.6	57.3	
15B	187	6590	441		
16B	76.8	5430	670	>100	
3A					53.4
48					40.6
40A					32.6
41					28.5
49					19.4
40B					14.5
11B					4.6
10f					7.7
10					3.4
11A					*
12					*
18					7
19					54

5

27

50

40.6

14

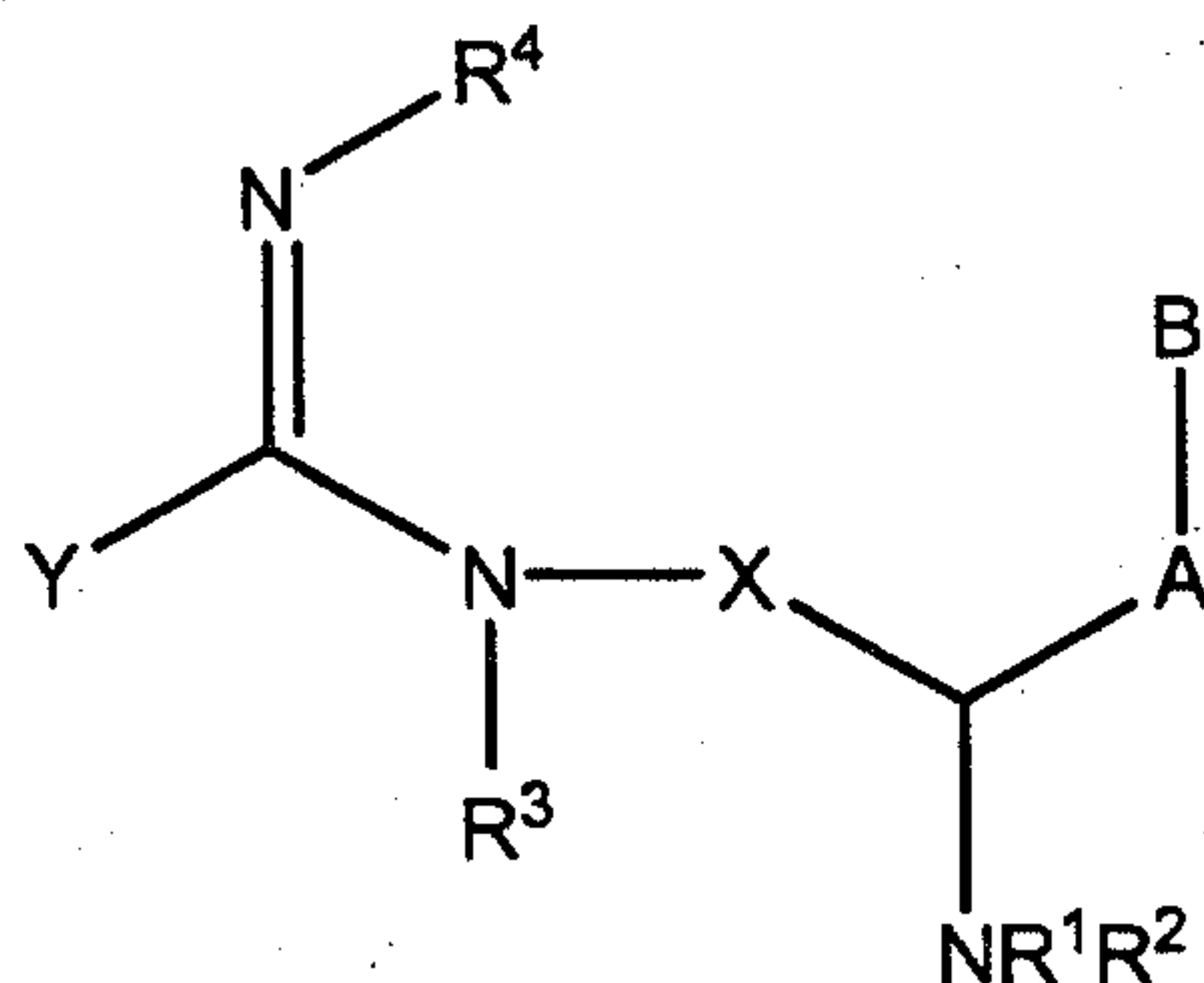
*

*At 100 μ M dose, response was not seen.

From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

What is claimed:

1. A compound or a pharmaceutically acceptable salt, prodrug or ester thereof having the formula:



Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(\text{CH}_2)_m\text{Q}(\text{CH}_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower

alkynyl radical, alicyclic hydrocarbon radical, carbonyl, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkoxycarbonyl, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, aromatic hydrocarbon radical, alicyclic hydrocarbon radical, or NHOH, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radical;

with the proviso that when A is CHOR, B cannot be OR and Y cannot be amino wherein R is alkyl;

with the proviso that when A is carbonyl, B is not hydroxy, aryloxy, thioalkoxy, alkoxy, or NHOH.

2. The compound as recited in claim 1 wherein;

Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all

said radicals may optionally be substituted with hydrogen, cyano, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

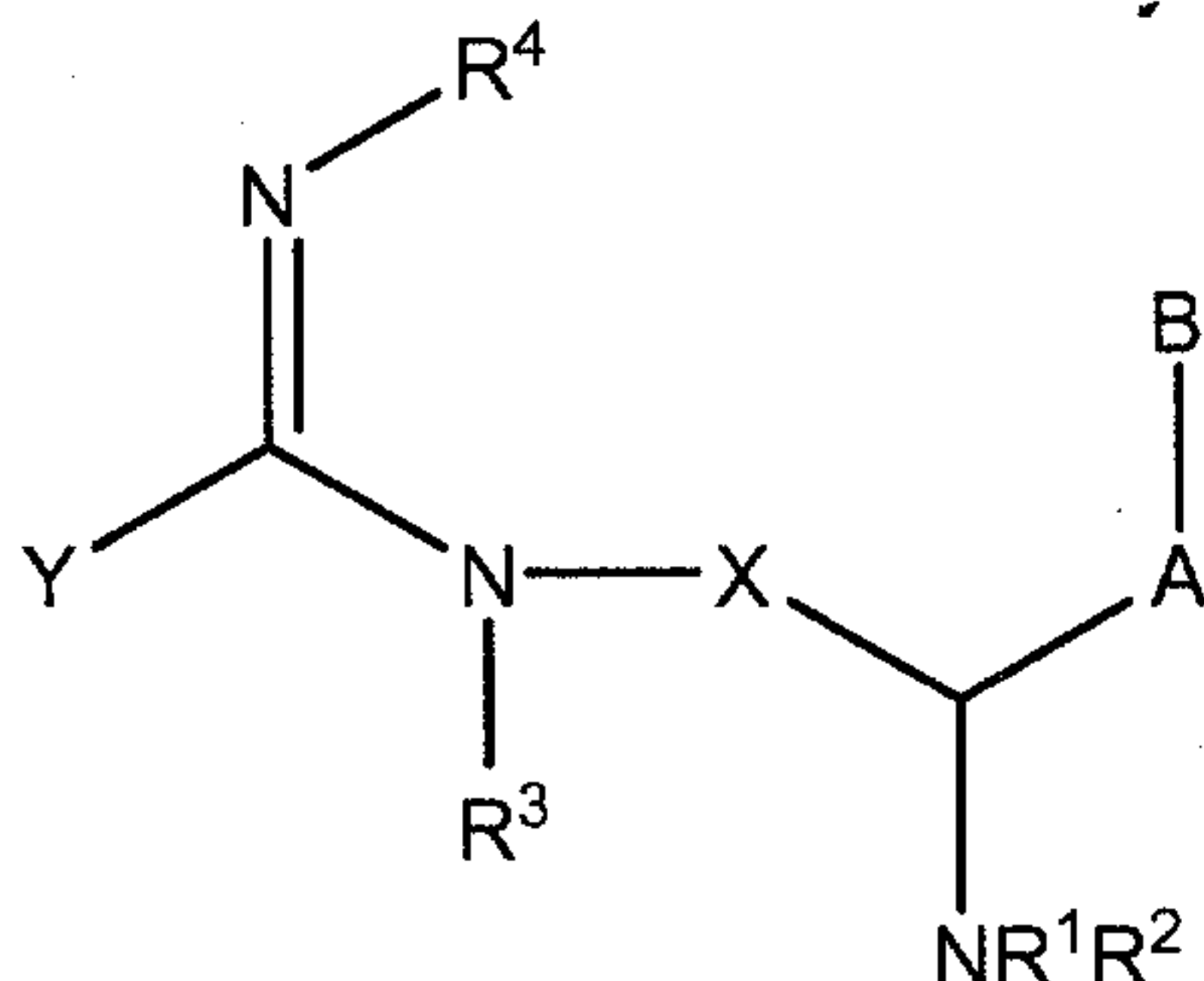
X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(CH_2)_mQ(CH_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, alicyclic hydrocarbon radical, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, or NHOH.

3. A compound or a pharmaceutically acceptable salt, prodrug or ester thereof having the formula:



wherein; Y is hydrogen or lower alkyl which may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene from 3-5 carbons which may optionally be substituted with hydrogen, halogen and lower alkyl;

R¹, R², R³ and R⁴ are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene from 2-4 carbons optionally substituted with hydroxyl; and

B is hydroxyl.

4. The compound as recited in claim 3 wherein;

Y is methyl;

X is butylene;

R¹, R², R³ and R⁴ are hydrogen;

A is ethylene or isopropylene optionally substituted with hydroxyl; and

B is hydroxyl.

5. The compound as recited in claim 1 wherein;

A is lower alkyl substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals.

6. The compound as recited in claim 1 wherein the compound is selected from the group consisting of;

N1-(1-iminoethyl)-1,4-pentanediamine;

N1-(1-iminoethyl)-1,5-heptanediamine;

N1-(1-iminoethyl)-5-phenyl-1,5-pentanediamine;

N-[5-amino-5-(2-hydroxyphenyl)pentyl]ethanimidamide;

N-[5-amino-5-(4-hydroxyphenyl)pentyl]ethanimidamide;

N-(5-aminononyl)ethanimidamide;

N-(5S-amino-6-oxoheptyl)ethanimidamide, dihydrochloride;

N-(5S-amino-6,7-dihydroxy-6-methylheptyl)ethanimidamide, hydrochloride dihydrate;

N-(5S-amino-6,7-dihydroxyoctyl)ethanimidamide,

dihydrochloride hydrate;

N- (5S-amino-6,7,8-trihydroxyoctyl)ethanimidamide;

N- (5S-amino-7,8-dihydroxyoctyl)ethanimidamide;

N- (5S-amino-6-hydroxy-7-methoxyheptyl)ethanimidamide;

N- [5S-amino-6-hydroxy-7- (ethylthio)heptyl]ethanimidamide;

N- [5S-amino-6-hydroxy-7-methylsulfinyl)heptyl]
ethanimidamide;

N- [5S-amino-6-hydroxy-7-methylsulfonyl)heptyl]
ethanimidamide;

N- [5S-amino-6-hydroxy-7- (phenylmethyl)thio]heptyl]
ethanimidamide;

N- [5S-amino-6-hydroxy-7- [(phenylmethyl)
sulfinyl]heptyl]ethanimidamide;

N- [5S-amino-6-hydroxy-7- [(phenylmethyl) sulfonyl]
heptyl]ethanimidamide;

N- (5S-amino-6-fluoro-7-hydroxy-6-methylheptyl)
ethanimidamide;

N- [5S-amino-6-hydroxy-7- (2-hydroxyphenyl)heptyl]
ethanimidamide, dihydrochloride;

N- [5S-amino-7,7,7-trifluoro-6-hydroxy-6-methylheptyl)
ethanimidamide;

N-(5S-amino-6-hydroxyheptyl)ethanimidamide,
dihydrochloride dihydrate;

N-[5S-amino-6-hydroxy-6-(2-hydroxyphenyl)hexyl]
ethanimidamide;

N-(5S-amino-6-hydroxyhexyl)ethanimidamide; and

α - [1-amino-5-[(1-iminoethyl)amino]pentyl]benzenemethanol
hydrochloride dihydrate.

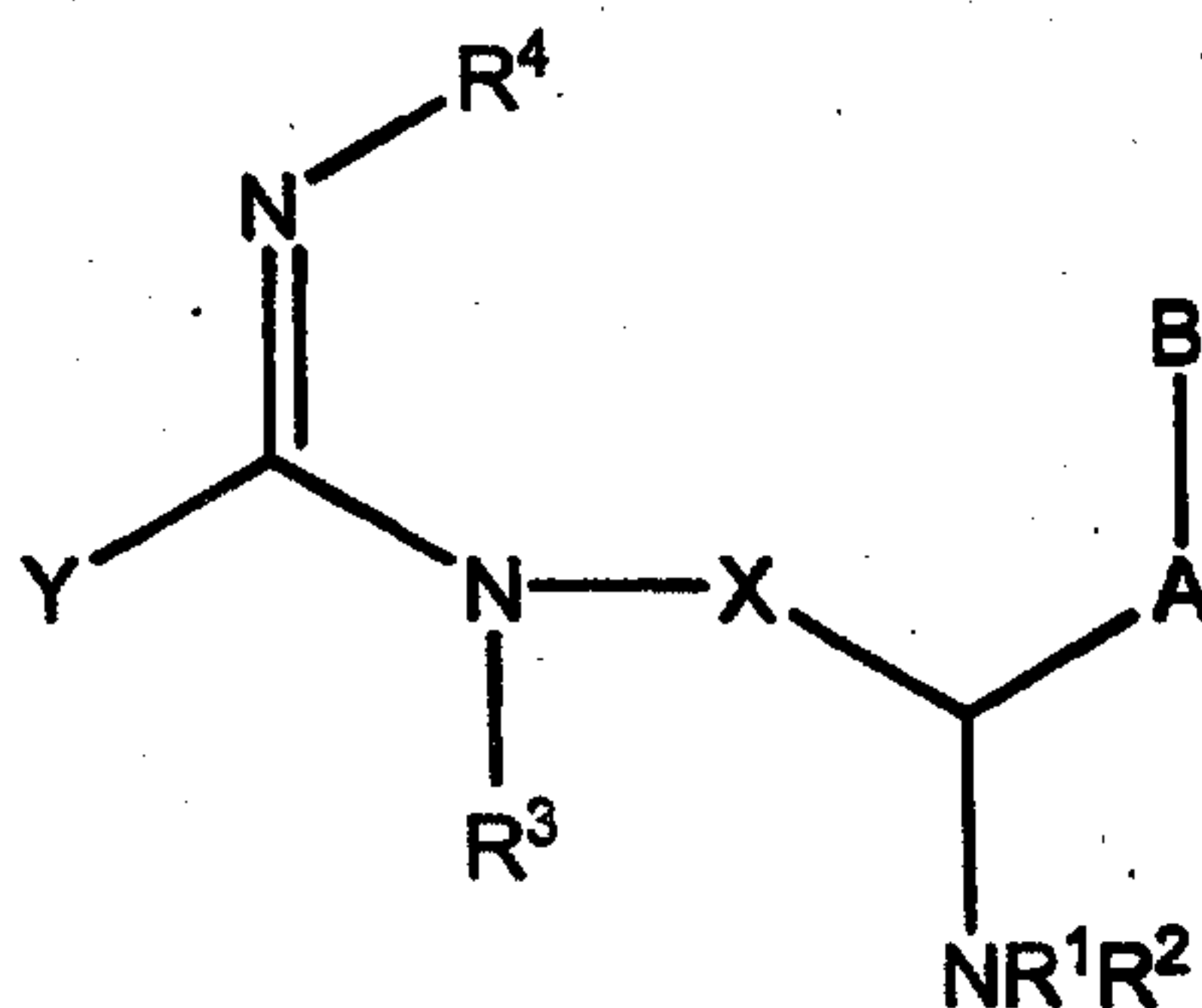
7. The compound as recited in claim 3 wherein the compound is selected from the group consisting of N-(5S-amino-6,7-dihydroxyheptyl)ethanimidamide, dihydrochloride; and N-(5S-amino-6,7-dihydroxy-6-methylheptyl)ethanimidamide, hydrochloride dihydrate.

8. A pharmaceutical composition comprising a compound as recited in claim 1 together with a pharmaceutically acceptable carrier.

9. A pharmaceutical composition comprising a compound as recited in claim 2 together with a pharmaceutically acceptable carrier.

10. A pharmaceutical composition comprising a compound as recited in claim 3, 4, 5, 6, or 7 together with a pharmaceutically acceptable carrier.

11. Use of a therapeutically effective amount of a compound having the formula:



wherein: Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(\text{CH}_2)_m\text{Q}(\text{CH}_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, alicyclic hydrocarbon radical, carbonyl, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkoxycarbonyl, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy,

thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, aromatic hydrocarbon radical, alicyclic hydrocarbon radical, or NHOH, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radical;

with the proviso that when A is CHOR, B cannot be OR and Y cannot be amino wherein R is alkyl;

with the proviso that when A is carbonyl, B is not hydroxy, aryloxy, thioalkoxy, alkoxy, or NHOH;

for inhibiting nitric oxide synthesis in a subject in need of such inhibition.

12. The use according to claim 11 wherein:

Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals may optionally be substituted with hydrogen, cyano, lower alkyl, nitro, amino, alicyclic

hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(CH_2)_mQ(CH_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

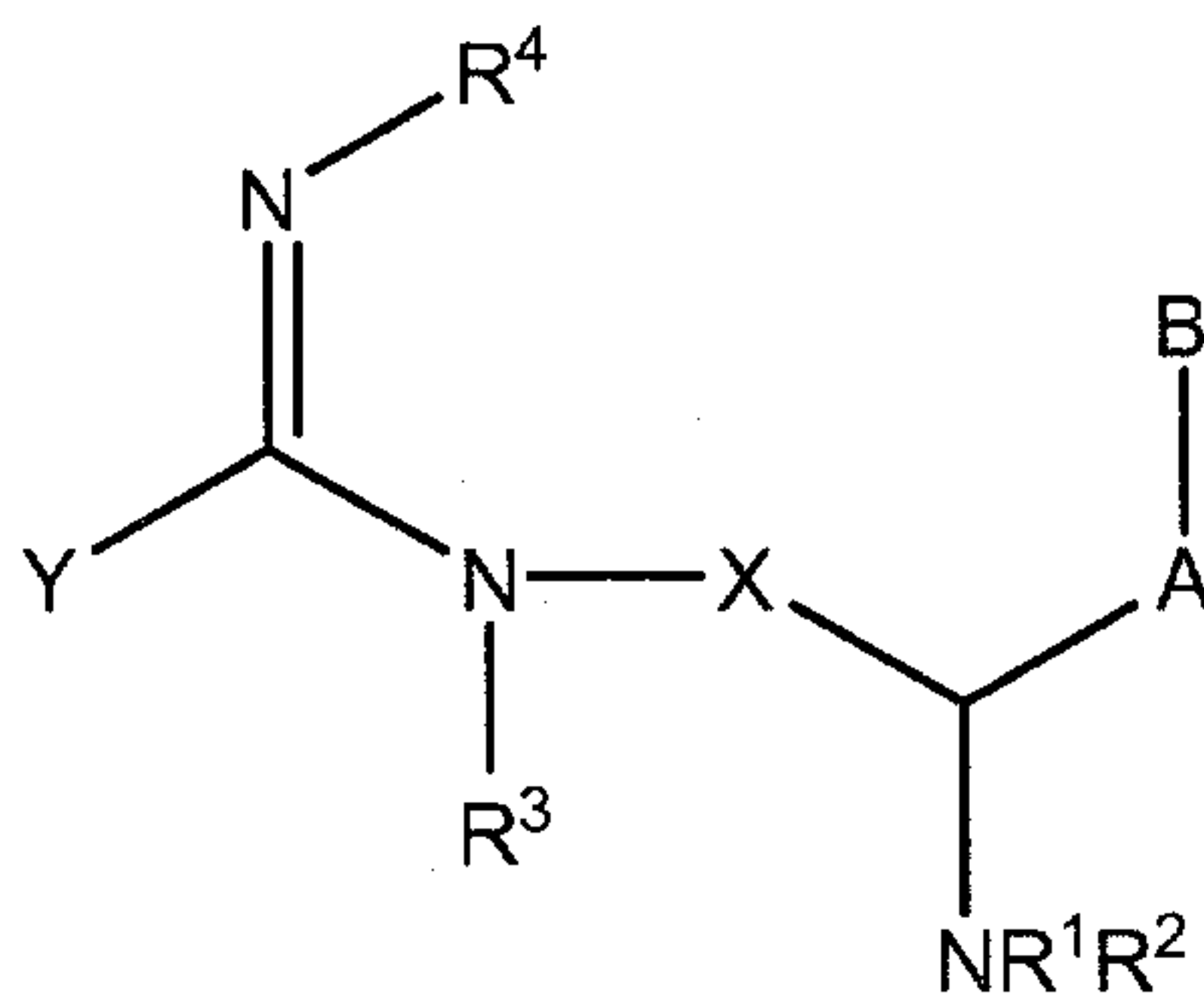
R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, alicyclic hydrocarbon radical, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, or NHOH.

13. Use of a therapeutically effective amount of a compound having the formula:

100



wherein: Y is hydrogen or lower alkyl which may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene from 3-5 carbons which may optionally substituted with hydrogen, halogen and lower alkyl;

R¹, R², R³ and R⁴ are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene from 2-4 carbons optionally substituted with hydroxyl; and

B is hydroxyl;

for inhibiting nitric oxide synthesis in a subject in need of such inhibition.

14. The use according to claim 13 wherein:

Y is methyl;

X is butylene;

R^1 , R^2 , R^3 and R^4 are hydrogen;

A is ethylene or isopropylene optionally substituted with hydroxyl; and

B is hydroxyl.

15. The use according to claim 11 wherein:

A is loweralkylene substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals.

16. The use according to claim 11 wherein the compound is selected from the group consisting of:

N1-(1-iminoethyl)-1,4-pentanediamine;

N1-(1-iminoethyl)-1,5-heptanediamine;

N1-(1-iminoethyl)-5-phenyl-1,5-pentanediamine;

N-[5-amino-5-(2-hydroxyphenyl)pentyl]ethanimidamide;

N-[5-amino-5-(4-hydroxyphenyl)pentyl]ethanimidamide;

N-(5-aminononyl)ethanimidamide;

N-(5S-amino-6-oxoheptyl)ethanimidamide, dihydrochloride;

N-(5S-amino-6,7-dihydroxy-6-methylheptyl)ethanimidamide, hydrochloride dihydrate;

N- (5S-amino-6,7-dihydroxyoctyl)ethanimidamide,
dihydrochloride hydrate;

N- (5S-amino-6,7,8-trihydroxyoctyl)ethanimidamide;

N- (5S-amino-7,8-dihydroxyoctyl)ethanimidamide;

N- (5S-amino-6-hydroxy-7-methoxyheptyl)ethanimidamide;

N- [5S-amino-6-hydroxy-7- (ethylthio)heptyl]ethanimidamide;

N- [5S-amino-6-hydroxy-7-methylsulfinyl)heptyl]
ethanimidamide;

N- [5S-amino-6-hydroxy-7-methylsulfonyl)heptyl]
ethanimidamide;

N- [5S-amino-6-hydroxy-7- (phenylmethyl)thio]heptyl]
ethanimidamide;

N- [5S-amino-6-hydroxy-7- [(phenylmethyl)
sulfinyl]heptyl]ethanimidamide;

N- [5S-amino-6-hydroxy-7- [(phenylmethyl) sulfonyl]
heptyl]ethanimidamide;

N- (5S-amino-6-fluoro-7-hydroxy-6-methylheptyl)
ethanimidamide;

N- [5S-amino-6-hydroxy-7- (2-hydroxyphenyl)heptyl]
ethanimidamide, dihydrochloride;

N- [5S-amino-7,7,7-trifluoro-6-hydroxy-6-methylheptyl)

ethanimidamide;

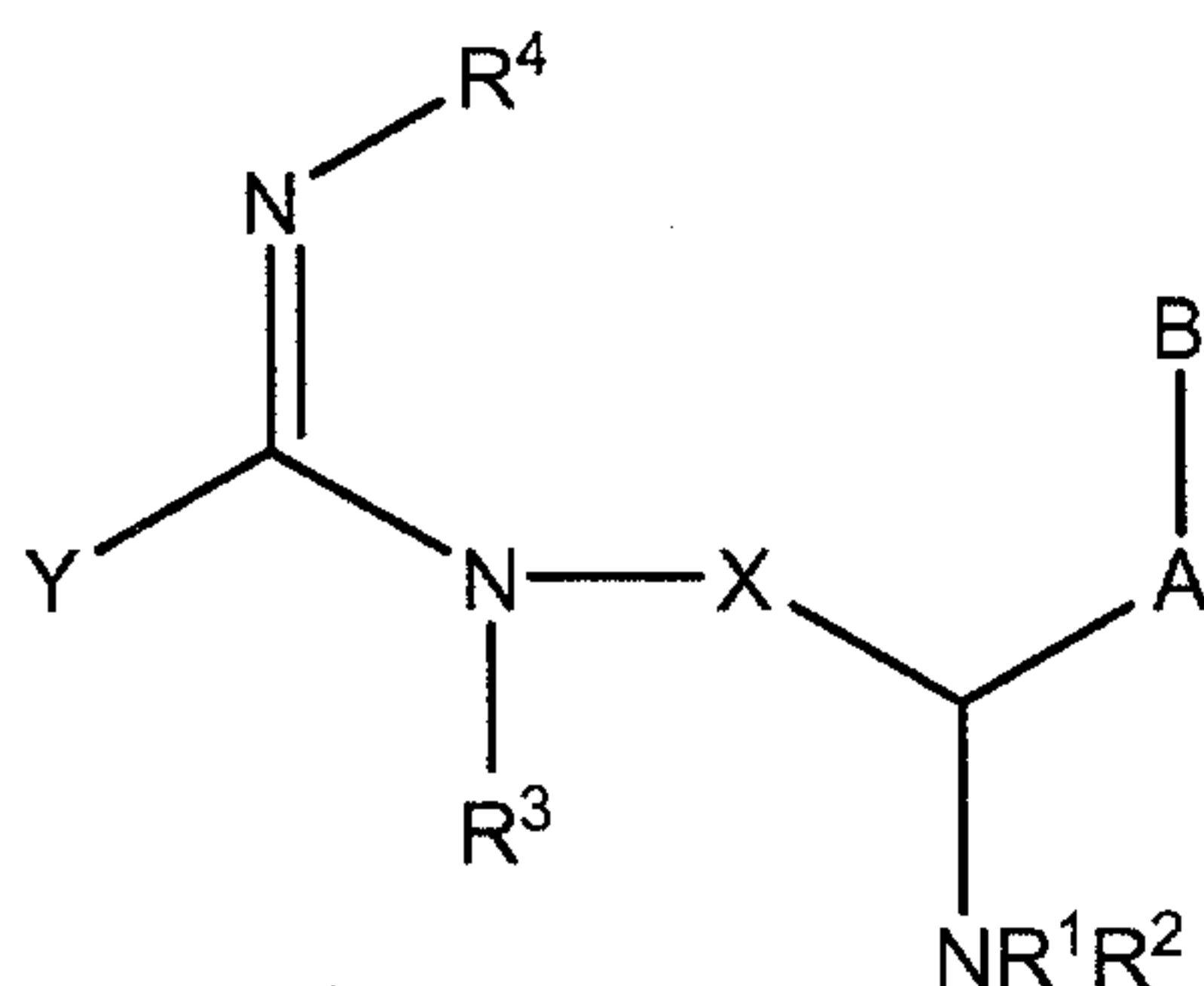
N-(5S-amino-6-hydroxyheptyl)ethanimidamide,
dihydrochloride dihydrate;

N-[5S-amino-6-hydroxy-6-(2-hydroxyphenyl)hexyl]
ethanimidamide;

N-(5S-amino-6-hydroxyhexyl)ethanimidamide; and

α - [1-amino-5-[(1-iminoethyl)aminopentyl]benzenemethanol
hydrochloride dihydrate.

17. Use of a therapeutically effective amount of a
compound having the formula:



wherein: Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(\text{CH}_2)_m\text{Q}(\text{CH}_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur,

sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, alicyclic hydrocarbon radical, carbonyl, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkoxycarbonyl, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, aromatic hydrocarbon radical, alicyclic hydrocarbon radical, or NHOH, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radical;

with the proviso that when A is CHOR, B cannot be OR and

Y cannot be amino wherein R is alkyl;

with the proviso that when A is carbonyl, B is not hydroxy, aryloxy, thioalkoxy, alkoxy, or NHOH;

for selectively inhibiting nitric oxide synthesis produced by inducible NO synthase over nitric oxide produced by the constitutive forms of NO synthase in a subject in need of such selective inhibition.

18. The use according to claim 17 wherein:

Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals may optionally be substituted with hydrogen, cyano, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(CH_2)_mQ(CH_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

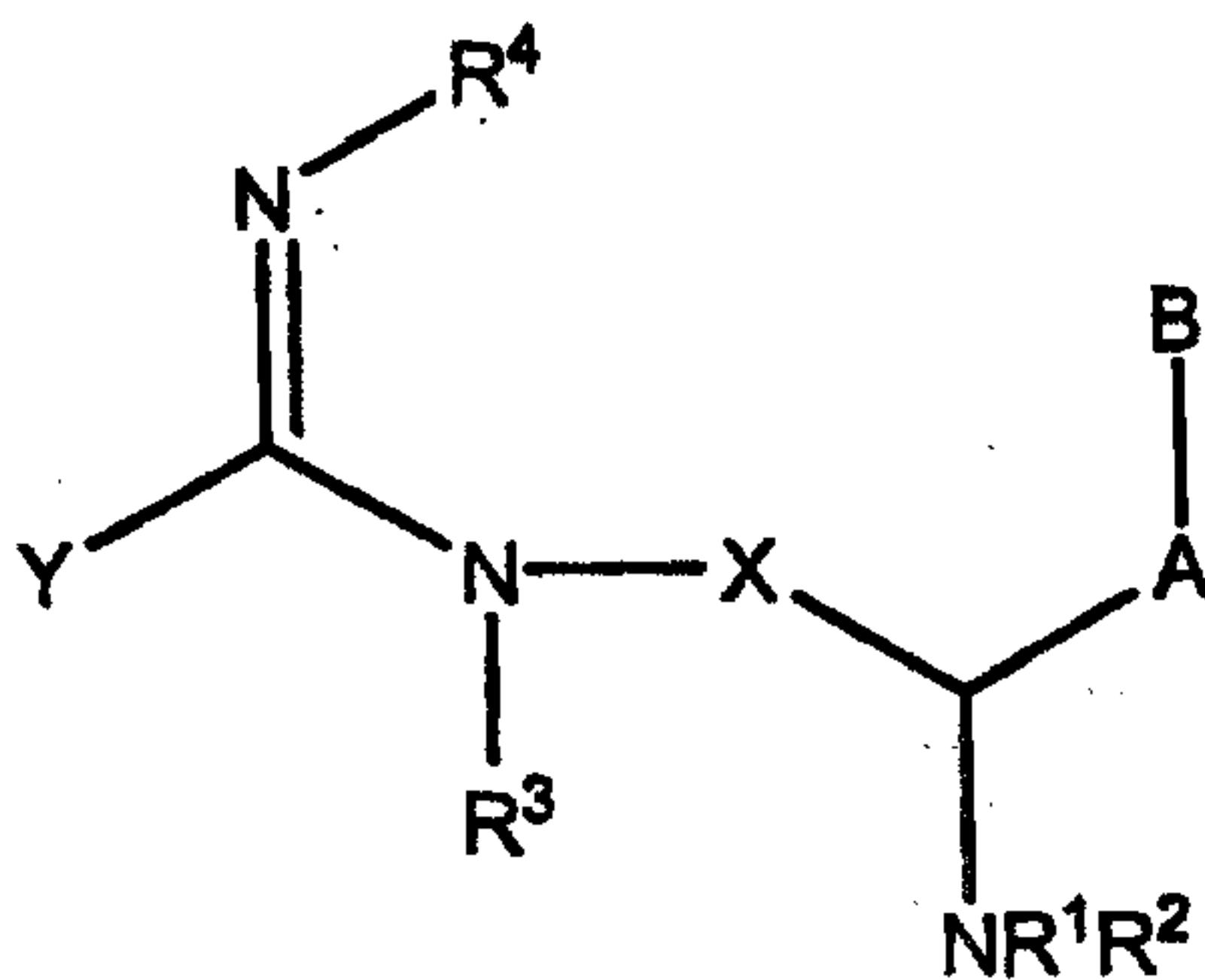
R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower

alkynylene radical, alicyclic hydrocarbon radical, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, or NHOH.

19. Use of a therapeutically effective amount of a compound having the formula:



wherein: Y is hydrogen or lower alkyl which may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene from 3-5 carbons which may optionally be substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene from 2-4 carbons optionally substituted with hydroxyl; and

B is hydroxyl;

for selectively inhibiting nitric oxide synthesis produced by inducible NO synthase over nitric oxide produced by the constitutive forms of NO synthase in a subject in need of such selective inhibition.

20. The use according to claim 19 wherein:

Y is methyl;

X is butylene;

R^1 , R^2 , R^3 and R^4 are hydrogen;

A is ethylene or isopropylene optionally substituted with hydroxyl; and

B is hydroxyl.

21. The use according to claim 17 wherein:

A is lower alkylene substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals.

22. The use according to claim 17 wherein the compound is

selected from the group consisting of:

N1-(1-iminoethyl)-1,4-pentanediamine;

N1-(1-iminoethyl)-1,5-heptanediamine;

N1-(1-iminoethyl)-5-phenyl-1,5-pentanediamine;

N-[5-amino-5-(2-hydroxyphenyl)pentyl]ethanimidamide;

N-[5-amino-5-(4-hydroxyphenyl)pentyl]ethanimidamide;

N-(5-aminononyl)ethanimidamide;

N-(5S-amino-6-oxoheptyl)ethanimidamide, dihydrochloride;

N-(5S-amino-6,7-dihydroxy-6-methylheptyl)ethanimidamide,
hydrochloride dihydrate;

N-(5S-amino-6,7-dihydroxyoctyl)ethanimidamide,
dihydrochloride hydrate;

N-(5S -amino-6,7,8-trihydroxyoctyl)ethanimidamide;

N-(5S-amino-7,8-dihydroxyoctyl)ethanimidamide;

N-(5S-amino-6-hydroxy-7-methoxyheptyl)ethanimidamide;

N-[5S-amino-6-hydroxy-7-(ethylthio)heptyl]ethanimidamide;

N-[5S-amino-6-hydroxy-7-methylsulfinyl)heptyl]
ethanimidamide;

N-[5S-amino-6-hydroxy-7-methylsulfonyl]heptyl]
ethanimidamide;

N-[5S-amino-6-hydroxy-7-(phenylmethyl)thio]heptyl]
ethanimidamide;

N-[5S-amino-6-hydroxy-7-[(phenylmethyl)
sulfinyl]heptyl]ethanimidamide;

N-[5S-amino-6-hydroxy-7-[(phenylmethyl)sulfonyl]
heptyl]ethanimidamide;

N-(5S-amino-6-fluoro-7-hydroxy-6-methylheptyl)
ethanimidamide;

N-[5S-amino-6-hydroxy-7-(2-hydroxyphenyl)heptyl]
ethanimidamide, dihydrochloride;

N-[5S-amino-7,7,7-trifluoro-6-hydroxy-6-methylheptyl]
ethanimidamide;

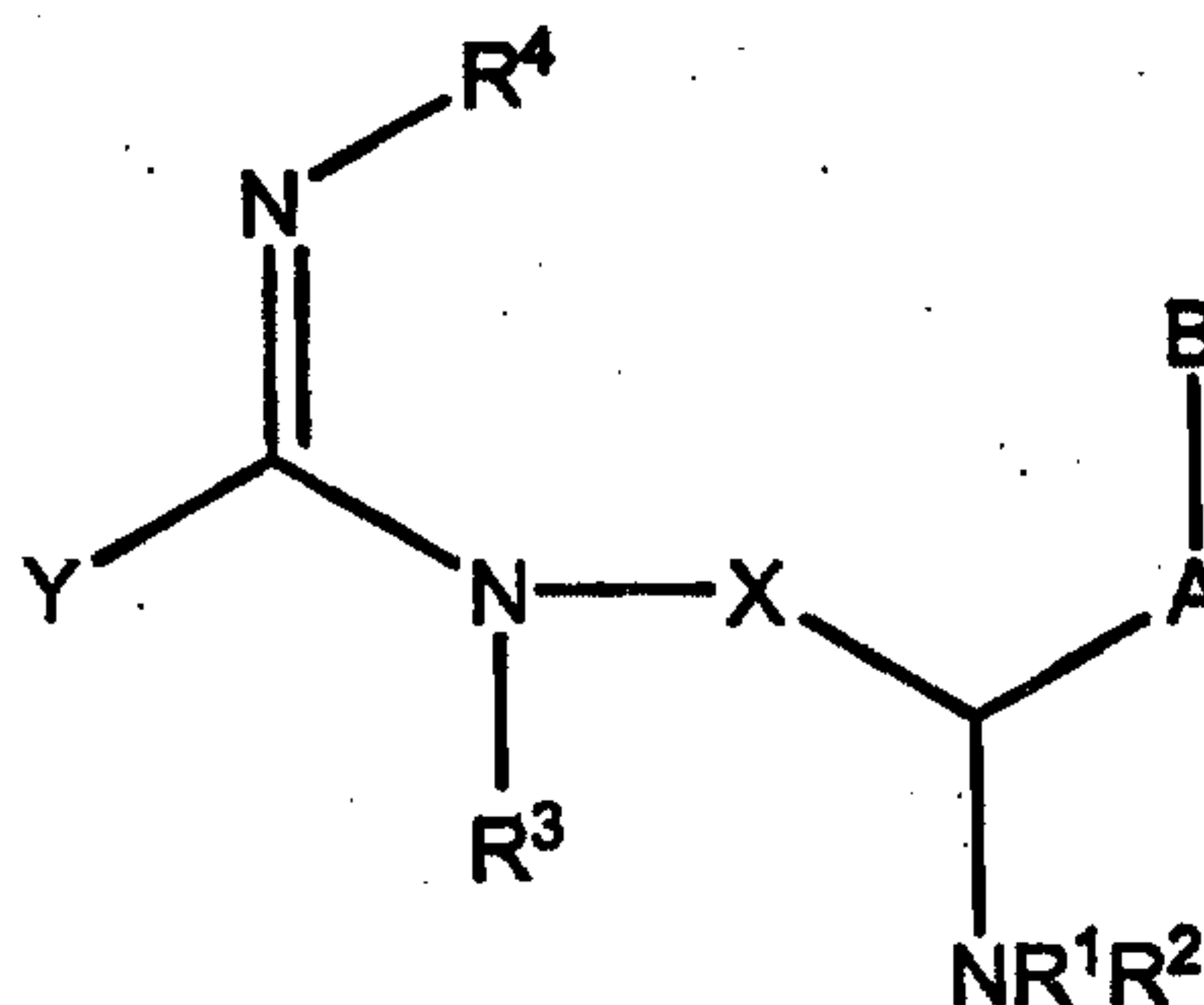
N-(5S-amino-6-hydroxyheptyl)ethanimidamide,
dihydrochloride dihydrate;

N-[5S -amino-6-hydroxy-6-(2-hydroxyphenyl)hexyl]
ethanimidamide;

N-(5S-amino-6-hydroxyhexyl)ethanimidamide; and

α -[1-amino-5-[(1-iminoethyl)amino]pentyl]benzenemethanol
hydrochloride dihydrate.

23. Use of a therapeutically effective amount of a compound having the formula:



wherein: Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(\text{CH}_2)_m\text{Q}(\text{CH}_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, alicyclic hydrocarbon radical, carbonyl, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower

alkyl, hydroxyl, lower alkoxy, alkoxycarbonyl, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, aromatic hydrocarbon radical, alicyclic hydrocarbon radical, or NHOH, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radical;

with the proviso that when A is CHOR, B cannot be OR and Y cannot be amino wherein R is alkyl;

with the proviso that when A is carbonyl, B is not hydroxy, aryloxy, thioalkoxy, alkoxy, or NHOH;

for inhibiting nitric oxide synthesis in a subject in need of such inhibition.

24. The use according to claim 23 wherein:

Y is hydrogen, lower alkyl radical, lower alkenyl radical, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all

said radicals may optionally be substituted with hydrogen, cyano, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

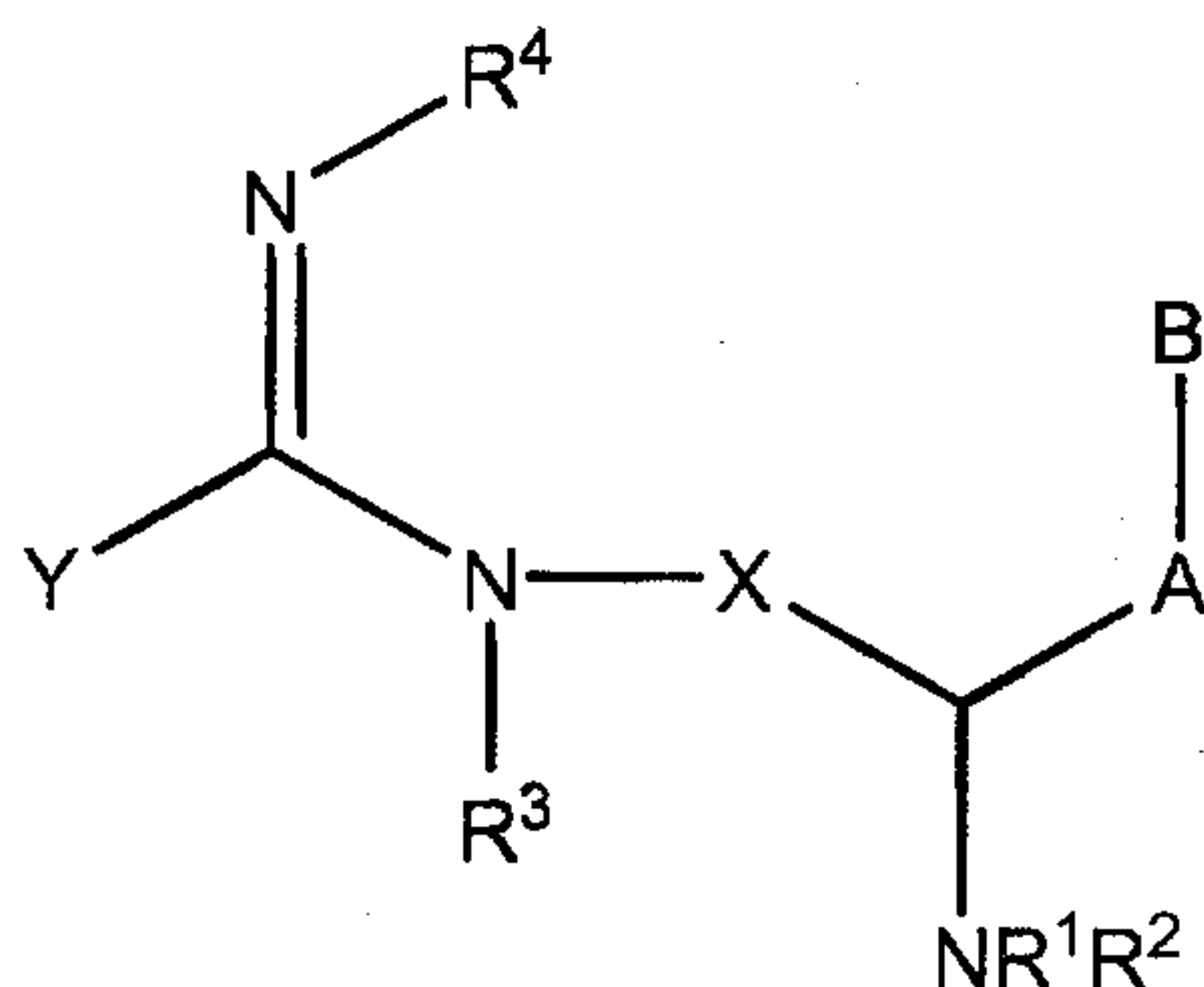
X is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, aromatic hydrocarbon radical, $(CH_2)_mQ(CH_2)_n$, where $m=1-3$, $n=1-3$, and Q is sulfur, sulfinyl, sulfonyl, oxygen, carbonyl, lower alkynyl radical, aromatic hydrocarbon radical, or alicyclic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, halogen and lower alkyl;

R^1 , R^2 , R^3 and R^4 are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene radical, lower alkenylene radical, lower alkynylene radical, alicyclic hydrocarbon radical, or aromatic hydrocarbon radical, wherein all said radicals are optionally substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, alkylaryloxy, thiol, lower thioalkoxy, thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals;

B is hydrogen, lower alkoxy radical, hydroxy, alkylaryloxy, thiol, lower thioalkoxy, lower thioalkylaryloxy, thioaryloxy, sulfinylalkyl, sulfinylalkylaryl, sulfinylaryl, sulfonylalkyl, sulfonylalkylaryl, sulfonylaryl, or NHOH.

25. Use of a therapeutically effective amount of a compound having the formula:



wherein: Y is hydrogen or lower alkyl which may optionally be substituted with hydrogen, lower alkyl, nitro, amino, alicyclic hydrocarbon radicals, or aromatic hydrocarbon radicals which may be optionally substituted with lower alkyl;

X is lower alkylene from 3-5 carbons which may optionally substituted with hydrogen, halogen and lower alkyl;

R¹, R², R³ and R⁴ are independently selected from the group consisting of hydrogen and lower alkyl;

A is lower alkylene from 2-4 carbons optionally substituted with hydroxyl; and

B is hydroxyl;

for inhibiting nitric oxide synthesis in a subject in need of such inhibition.

26. The use according to claim 23 wherein:

Y is methyl;

X is butylene;

R¹, R², R³ and R⁴ are hydrogen;

A is ethylene or isopropylene optionally substituted with hydroxyl and

B is hydroxyl.

27. The use according to claim 23 wherein:

A is lower alkylene substituted with hydrogen, lower alkyl, hydroxyl, lower alkoxy, halogen, aromatic hydrocarbon radicals, or alicyclic hydrocarbon radicals.

28. The use according to claim 23 wherein the compound is selected from the group consisting of:

N1-(1-iminoethyl)-1,4-pentanediamine;

N1-(1-iminoethyl)-1,5-heptanediamine;

N1-(1-iminoethyl)-5-phenyl-1,5-pentanediamine;

N-[5-amino-5-(2-hydroxyphenyl)pentyl]ethanimidamide;

N-[5-amino-5-(4-hydroxyphenyl)pentyl]ethanimidamide;

N-(5-aminononyl)ethanimidamide;

N-(5S-amino-6-oxoheptyl)ethanimidamide, dihydrochloride;

N-(5S-amino-6,7-dihydroxy-6-methylheptyl)ethanimidamide,

hydrochloride dihydrate;

N-(5S-amino-6,7-dihydroxyoctyl)ethanimidamide,
dihydrochloride hydrate;

N-(5S-amino-6,7,8-trihydroxyoctyl)ethanimidamide;

N-(5S-amino-7,8-dihydroxyoctyl)ethanimidamide;

N-(5S-amino-6-hydroxy-7-methoxyheptyl)ethanimidamide;

N-[5S-amino-6-hydroxy-7-(ethylthio)heptyl]ethanimidamide;

N-[5S-amino-6-hydroxy-7-methylsulfinyl]heptyl]
ethanimidamide;

N-[5S-amino-6-hydroxy-7-methylsulfonyl]heptyl]
ethanimidamide;

N-[5S-amino-6-hydroxy-7-(phenylmethyl)thio]heptyl]
ethanimidamide;

N-[5S-amino-6-hydroxy-7-[(phenylmethyl)
sulfinyl]heptyl]ethanimidamide;

N-[5S-amino-6-hydroxy-7-[(phenylmethyl)sulfonyl]
heptyl]ethanimidamide;

N-(5S-amino-6-fluoro-7-hydroxy-6-methylheptyl)
ethanimidamide;

N-[5S-amino-6-hydroxy-7-(2-hydroxyphenyl)heptyl]
ethanimidamide, dihydrochloride;

N-[5S-amino-7,7,7-trifluoro-6-hydroxy-6-methylheptyl]
ethanimidamide;

N-(5S-amino-6-hydroxyheptyl)ethanimidamide,
dihydrochloride dihydrate;

N-[5S-amino-6-hydroxy-6-(2-hydroxyphenyl)hexyl]
ethanimidamide;

N-(5S-amino-6-hydroxyhexyl)ethanimidamide; and

α -[1-amino-5-[(1-iminoethyl)amino]pentyl]benzenemethanol
hydrochloride dihydrate.